AIEE SPECIAL PUBLICATIONS
Order Form—Page 32A

ELECTRICAL ENGINEERING

AUGUST 1950

PUBLISHED MONTHLY BY THE AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

For 1 to $3^1/_2$ Million KVA

INTERRUPTING CAPACITY - 69 KV

- **MECHANICALLY TRIP-FREE PNEUMATIC OPERATOR** *assures positive tripping*
- **SINGLE-BREAK *RUPTOR* DEVICE** *(5 cycle interruption if required) for low arc energy release*
- **EVERY BREAKER** *factory assembled, tested, and shipped without dismantling.*

INSTANT, POSITIVE CONTACT OPENING under all conditions is *assured* with FZO-151 breakers. The reason is Allis-Chalmers mechanically trip-free pneumatic operator. In case of a fault, the operator is effectively uncoupled from contact mechanism by means of a positive mechanical linkage. Contacts open *independent of valve operation or cylinder back pressures* . . . there's nothing to hinder instant tripping.

Positive operation is further assured with simple, single-break *Ruptor* interrupting device that extinguishes arc without use of unnecessary moving parts that may bind or fail. Self-cleaning action of bayonet-type moving contacts prevents formation of high resistance oxides. Low inertia pole unit mechanism of straight line motion type gives high speed interruption with low arc energy release.

Complete factory test data accompanies every breaker. For details on Allis-Chalmers breakers for any utility need, contact your A-C sales office.

ALLIS-CHALMERS, 931A SO. 70 ST.
MILWAUKEE, WIS.

STANDARD RATINGS
(8 cycle interruption)

Rated KV	Rated amp. 60 cycle	KVA Interrupting Capacity
69	600	1,000,000
69	1200	1,500,000
69	1200	2,500,000
69	2000	3,500,000

GET NEW BULLETIN
71B7045 for ratings, dimensions and details of construction of type FZO-151 breakers.

A-3073

Ruptor is an Allis-Chalmers trademark

ALLIS-CHALMERS

A-C ALLIS-CHALMERS

ELECTRICAL ENGINEERING

Registered United States Patent Office

AUGUST 1950

VOL. 69 NO. 8

 Published monthly by the

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Founded 1884

Headquarters
33 West 39th Street
New York 18, N. Y.

Editorial Offices
500 Fifth Avenue
New York 18, N. Y.

HIGHLIGHTS........

The Cover. The lightning stroke shown on this month's cover apparently is a so-called multiple stroke consisting of a first so-called current peak or high current discharge at the left, as indicated by the high-intensity band about two millimeters wide. This first discharge is followed without interruption by a so-called continuous current discharge, which is the broad band of lower intensity. Subsequently, four more high current peaks can be seen to the right of the continuing current period. Approximately $2^1/_2$ inches above the roof on the first current peak at left, there appears what looks like an upward streamer or split in the discharge path. Unless this is a downward streamer partly hidden by the remainder of the stroke, this would be an indication of a rather high upward streamer occurring during the formation of the discharge. Its height would be approximately 150 feet, which is interesting because evidence of streamers from the ground meeting the cloud-to-ground leader stroke in the formative process is very meager. Another interesting feature is the great change in the bends and twists of the stroke channel which is probably due to the strong wind blowing at the time. (*J. H. Hagenguth, Engineer in Charge, General Electric High Voltage Laboratory*)

The President Looks Ahead. T. G. LeClair, incoming AIEE President for 1950–51, looks at the problems incidental to the phenomenal growth of the Institute within the past few years. The two most important problems are: the internal operations of the Institute, and the question of unity in the engineering profession as a whole (*pages 667–8*). In regard to the latter problem, a tabulation of the result of the 1950 Membership Opinion Poll on Institute Policy is included in this issue (*page 669*).

Lamme Medal. The Lamme Medal for 1949 has been awarded to C. M. Laffoon of the Westinghouse Electric Corporation. During the presentation ceremonies, Past-President J. F. Fairman gave the history of the medal, while A. W. Copley recounted the Medalist's achievements. In his response, Mr. Laffoon discussed the progress of engineering design (*pages 670–2*).

News Index

Summer and Pacific Meeting. A combined AIEE Summer and Pacific General Meeting was held this year in Pasadena, Calif., June 12–16. A full report of the meeting's technical session, as well as the general and social activities, is included in this issue (*pages 728–33*). Short authors' digests of most of the conference papers which were presented during this meeting also are included (*pages 717–26*).

Directors' Report. The 66th annual report of the AIEE Board of Directors is presented in full in this issue. Covering the fiscal year ending April 30, 1950, it contains a brief summary of Institute activities and statements of the financial status of the Institute (*pages 738–64*).

Special Purpose Batteries. In the third article in a series on batteries, a member of the Signal Corps discusses the special-purpose batteries which had to be developed for use with certain types of Army and Air Corps equipment (*pages 701–04*).

Gaseous Tube Rectifiers. The fundamental processes occurring in gaseous rectifiers are discussed by A. W. Hull, consultant to the General Electric Research Laboratories. The phenomena which takes place in both high-pressure and low-pressure gas tubes is described, and uses of these tubes are investigated (*pages 695–700*).

Dynamoelectric Amplifiers. The dynamoelectric amplifier is sufficiently similar to the electronic amplifier that much which has been written about the electronic type can be applied in predicting performance characteristics of the dynamoelectric type. All recent dynamoelectric amplifiers operating under Class *A* condition can be represented by an equivalent circuit which can be used to predict the dynamic characteristics from the a-c steady-state analysis (*pages 711–16*).

Analyzing Contactor Servomechanisms. In order to analyze performance of an existing servomechanism or to synthesize a servomechanism from desired performance, a method of approximation is proposed by Dr. Ralph J. Kochenburger of the Electrical Engineering Department of the University of Connecticut. The method may also be used to design compensating networks to improve the performance of existing servomechanism systems, and it can be used in analysis and synthesis of nonlinear systems involving such elements as backlash or saturation (*pages 687–92*).

AIEE Proceedings

Order forms for current AIEE *Proceedings* have been published in *Electrical Engineering* as listed below. Each section of AIEE *Proceedings* contains the full, formal text of a technical program paper, including discussion, if any, as it will appear in the annual volume of AIEE *Transactions.*

AIEE *Proceedings* are an interim membership service, issued in accordance with the revised publication policy that became effective January 1947 (*EE, Dec '46, pp 567–8; Jan '47, pp 82–3*). They are available to AIEE Student members, Associates, Members, and Fellows only.

All technical papers issued as AIEE *Proceedings* will appear in *Electrical Engineering* in abbreviated form.

Location of Order Forms	Meetings Covered
Jul '49, p 47A	South West District Summer General
Nov '49, p 51A	Pacific General Fall General
Feb '50, p 46A	Winter General
Jul '50, p 30A	Winter General North Eastern District Great Lakes District Summer and Pacific General (1950)

Lightning Performance of Hoover Transmission Lines. The performance of the 287.5-kv transmission lines from Hoover Dam to Los Angeles when subjected to lightning conditions is described this month. During the 13 years the line has been in operation, data have been recorded to show variations of lightning intensity and frequency with location and season (*pages 706–08*).

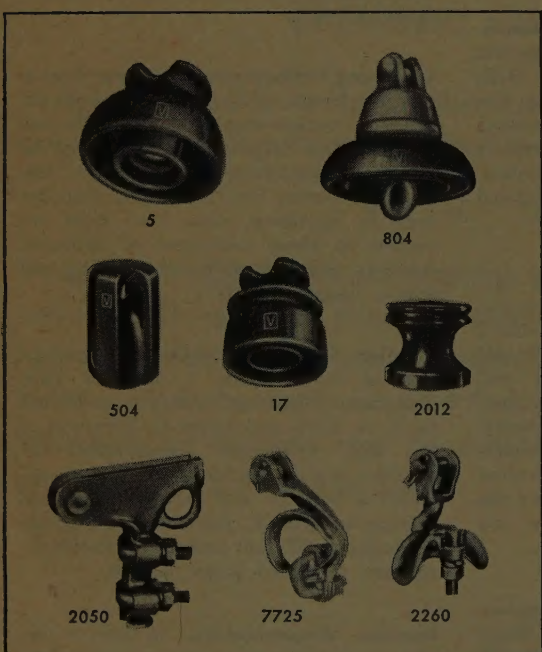
Number 5 Crossbar System. A description of the Number 5 Crossbar Dial Telephone Switching System is presented by F. A. Korn and James G. Ferguson of the Bell Telephone Laboratories. In addition to a description of the equipment, which is versatile and may be used with existing equipment, discussions and circuit diagrams of different phases of a telephone call are presented (*pages 679–84*).

Impulse Measurements. In order to obtain accurate measurement and recording of impulse voltage forms, a study has been made of the use of repeated-structure networks for this purpose. Laboratory tests of these networks show that they give much better results than have been obtainable up to now. A description of some of the networks tested and the results of the tests are given in this issue (*pages 673–7*).

ELECTRICAL ENGINEERING. Published monthly by the American Institute of Electrical Engineers; publication office 20th & Northampton Streets, Easton, Pa. Editorial and advertising offices 500 Fifth Avenue, New York 18, N. Y. Subscription $12 per year plus extra postage charge to all countries to which the second-class postage rate does not apply; single copy $1.50. Entered as second-class matter at the Post Office, Easton, Pa., under the Act of Congress of March 3, 1879. Accepted for mailing at special postage rates provided for in Section 538, P. L. & R. Act of February 28, 1925. August 1950, Vol. 69, No. 8. Number of copies of this issue 52,100

ONE SOURCE: VICTOR

For distribution insulators and line hardware



YES, you can rely on VICTOR *alone* for *all* your distribution insulator and line hardware requirements . . . from pintype, spool, guy strain and dead-ending insulators, to strain and angle clamps of the highest quality. And, when you standardize on VICTOR, you—

CUT DISTRIBUTION COSTS 2 WAYS

1. *Less maintenance*—because these distribution insulators are ruggedly designed and made of the best "high voltage" porcelain to give you continuous, *trouble-free* performance under *all* kinds of operating conditions.

2. *Fewer replacements*—because each distribution insulator is thoroughly inspected and rigidly tested at *every* point of manufacture. This *guarantees* you top performance on-the-job.

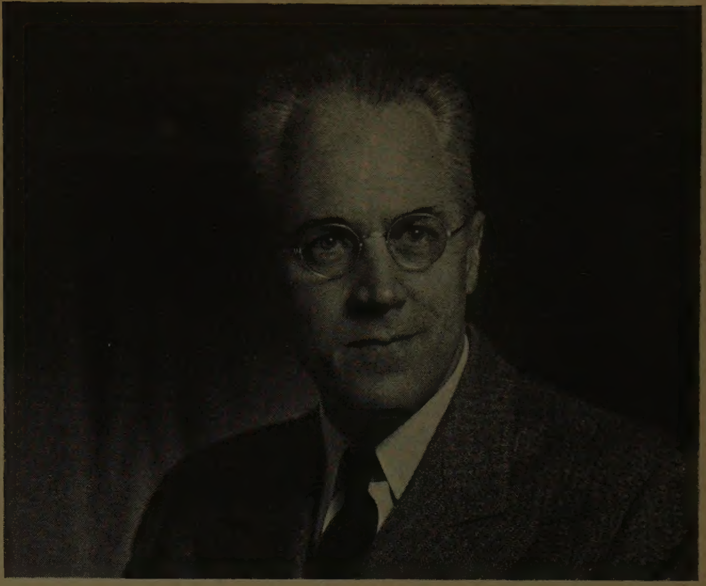
So, on your next distribution job, standardize on VICTOR.

Now Available—

VICTOR'S ALL-NEW CONDENSED CATALOG

Write for your copy today!

The President Looks Ahead



T. G. LECLAIR
PRESIDENT AIEE

The incoming President discusses some of the problems which face the Institute as it enters a new year of expanded growth and activity.

I AM INDEED honored to accept the badge of office as President of the AIEE. It had never occurred to me that the 25 years of active work in the Institute which began with a small committee assignment in the Chicago Section would ever lead to the honor of serving as AIEE President. During those years, every assignment as a committee member, a committee chairman, or as an officer has brought a distinct feeling of satisfaction and pleasure in associating with this fine group of leading engineers and has repaid many times any small service which I may have rendered.

President Fairman and his fellow officers in the last few years have been responsible for a phenomenal growth on the part of the Institute. This growth has been accomplished by an expansion in the Institute's activities and this expanded activity creates a few problems for us to solve in the future.

The Institute has now become a big business with its 35,000 members and 20,000 students. It is representative of a strong body of high-minded citizens. The Institute has assets of over a million dollars and an annual income approaching a million dollars, and all the responsibilities which these entail.

THE TASK AHEAD

As I see the task ahead of us, the Institute faces two important problems on which there is much work yet to be done. The first problem concerns the internal operations of the Institute, including the Sections, Student Branches, and committees, as well as presentation of papers, and publications.

Some of you may be old enough to remember that the Institute of Radio Engineers was founded because an active and wide-awake group of young men felt that the AIEE was devoting too little time to the problems which faced the communication engineer. Consequently, they formed a new organization to fill their needs. In the more recent expansion which has come since the end of the war and the rapid growth in the number and complexity of new electrical technical problems, the Institute has been more farsighted. With each new problem, new committees have been formed until there are now some 45 technical committees and almost an equal number of general committees, in addition to the vast number of Sections and Student Branches.

It is no longer possible for a small Board of Directors to know all the things that are going on in all of these many committees. Consequently, we are in the process of setting up separate divisions, each of which will have an increasing amount of freedom to take care of its own affairs, set up its own programs, and have its own meetings. Formalizing this program, providing for it properly in the constitution and bylaws, and getting the organization to run smoothly is one of the big problems of the immediate future. Fortunately, the active people in these committees for the past two or three years have recognized the situation and have been giving it close and co-operative attention.

To solve these current problems within the Institute, it is necessary to have continuity in the operation of our committees and of the management of the Institute. It is a pleasure to report that all of the committee chairmen for the year 1950–51 were selected and accepted their assignments before the Summer and Pacific General Meeting. Each of these committee chairmen is a recognized leader in his field and we can be proud and confident with the work of the Institute in their hands for the coming year. The entire committee membership is ready to take over the reins immediately at the turn of the administrative year.

PROBLEM OF UNITY

The second problem which the Institute still faces is that of unity in the engineering profession as a whole. Engineering as a profession is too important a factor in the

Full text of the address presented in acceptance of the President's badge at the AIEE Summer and Pacific General Meeting, Pasadena, Calif., June 12–16, 1950.

T. G. LeClair is Chief Electrical Engineer, Commonwealth Edison Company, Chicago, Ill.

welfare of the United States for us to permit any minor disagreements among engineers in the various specialties to interfere with the advancement of the profession and the standing of the profession as a builder of the nation's economy.

The Institute can take pride in the fact that we have been among the more active groups in the country in attempting to stimulate better relations with other societies and attempting to set up an organization which will be truly representative of the profession as a whole. Our activity in determining the wishes of the membership was the first effort of this kind ever undertaken. It was largely through the stimulation by your representatives on the Engineers Joint Council that the 16 engineering societies met and began a joint study to determine the best form of unity organization for the profession (see this issue, page 765). When a final plan is agreed upon and a method of attaining this plan is set up, we must all plan to work together putting it into effect in order to make unification a real and live thing.

Perhaps, to accomplish this goal, the Institute will have to give up a small amount of its independence in acting on nontechnical matters, but if so, the returns in a larger stature for the engineering profession will be far greater than any sacrifice which we may make in a small portion of our activity.

One of the earliest published references to an engineering project is the first nine verses of the 11th Chapter of the Book of Genesis. If you remember your Sunday School lessons, you will remember that this is the story of the building of the Tower of Babel. You may also remember that the building of the tower stopped and the strength of the peoples was lost because they got so far apart that they no longer spoke the same tongue. We are building a bigger profession, but we must be careful lest we make it a Tower of Babel.

You electrical engineers in the power field, let us have the power to hold the profession together; you communication engineers certainly know that communication is the tool of understanding; and you who are educators, let us educate the entire profession to the importance of standing together as a single profession in which the various specialities are only a part of our broader goal to raise the standard of living by designing new and better tools for the service of man. Let us all speak the same language and work together to build a bigger and better profession.

World's First Submerged Transatlantic Cable Amplifier

Development of the world's first submerged transatlantic cable amplifier, which can increase the annual capacity of the Western Union Telegraph Company's cable system by more than a hundred million words and have far-reaching effects on the future of global communications, was announced recently by the company.

The first amplifier has been inserted in a transatlantic cable 1,800 feet down on the ocean bottom northeast of Newfoundland and is expected to double the speed of that cable. Use of the amplifier on additional cables will provide new high-speed all-weather arteries for world communication. Furthermore, the new amplifier should have the effect of greatly reducing the frequency demands in an already crowded global radio spectrum.

Use of the new amplifier will enable the cables to handle international communications instantaneously for the United States government and military, in addition to that of our allies and the press, in time of national emergency and, at the same time, provide a surplus of facilities for normal peacetime requirements.

The 3-stage vacuum-tube amplifier is somewhat similar in its function to the amplifier in a home radio-broadcast receiver. Attached to a cable about 200 miles at sea, the amplifier increases message capacity by amplifying and reshaping the wavefront of signals which have become weak in traveling from the remote end of the cable. The equipment is sealed in a rectangular steel case about five feet long and a foot square. The whole unit weighs approximately 1,100 pounds.

The first amplifier was installed by the Western Union Cable Ship, *Cyrus Field*, in one of the older cables, laid in 1881, and connecting Penzance, England, and Bay Roberts, Newfoundland. The location is about 165 miles northeast of Bay Roberts, just beyond the Newfoundland Banks.

The depth of the ocean at the point of installation is about 1,800 feet, which is sufficient to insure that the amplifier will be safe from ships' anchors, the nets of fishing trawlers, and other hazards present in shallower water. The cable ship hooked the cable with a grapnel and raised it to the deck of the ship. The amplifier was then spliced into the cable and the cable was lowered to the ocean bottom.

Space in the amplifier casing that is not occupied by the electrical equipment is filled with oil. A pressure-equalizing device automatically adjusts the pressure within the case to the external sea bottom pressure of nearly 800 pounds per square inch, resulting from the weight of the water above. This is roughly four times the steam pressure commonly used in railroad locomotives. The pressure equalizer is a piston-cylinder and a bellows constructed of monel metal that sea water will not corrode. The cable conductors enter the case through insulating glands which keep sea water out.

Electric power for the equipment will be supplied from the Western Union Cable Station at Bay Roberts over the single cable conductor on which the signals also are transmitted. Three complete sets of vacuum tubes are enclosed in the amplifier. An electrically operated switch, controlled from the station, will change tubes in the event of tube failure.

1950 Membership Opinion Poll on Institute Policy

—A Tabulation of Results—

A report on the 1949 Membership Opinion Poll on Institute Policy was published in the March 1950 issue of *Electrical Engineering*, page 194, with a return postal card upon which members were requested to indicate their approval or disapproval of three proposals of policy which had been prepared on the basis of the results of the 1949 poll. A tabulation of the results of the 1950 poll is presented herewith. The three proposals submitted are

1. To work continually for the unification of the profession.
2. To recognize the fact that the Institute finds its chief reason for existence in the technical field.
3. To handle questions on nontechnical affairs as necessary and as they arise, on an emergency basis until through unification they can be handled on a general professional basis.

The Board of Directors, at its meeting on June 15, 1950, directed that the tabulation on the 1950 poll be published in *Electrical Engineering*, with the conclusion that the membership, as represented by the poll, endorses the three proposals, and a statement to the effect that the Board of Directors of the AIEE will, therefore, be guided by these three proposals in making all of its decisions concerning Institute activities.

Result of 1950 AIEE Membership Opinion Poll

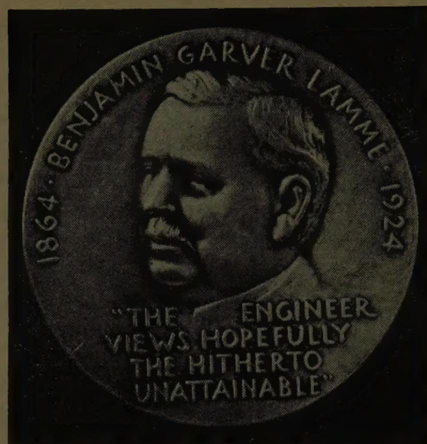
To June 1, 1950

Sections		Proposal No. 1		Proposal No. 2		Proposal No. 3	
		Approved	Disapproved	Approved	Disapproved	Approved	Disapproved
District 1							
Boston	(833)	94	9	101	5	94	10
Connecticut	(490)	69	3	65	5	66	5
Ithaca	(180)	28	2	28	1	28	2
Lynn	(266)	34	3	36		33	4
Niagara Frontier	(266)	42	1	42	1	41	3
Pittsfield	(282)	78	2	73	6	74	4
Providence	(132)	22	2	20	5	22	3
Rochester	(214)	27	1	28	2	27	1
Schenectady	(928)	94	8	92	9	90	7
Springfield	(88)	14	2	15		15	1
Syracuse	(237)	26	1	25	2	25	2
Worcester	(88)	31	3	27	5	33	3
	(4,004)	559	37	552	41	548	45
District 2							
Akron	(118)	10	2	13	1	12	1
Canton	(79)	17	1	16	1	14	2
Cincinnati	(236)	16	2	17	1	17	1
Cleveland	(708)	105	6	102	9	103	9
Columbus	(137)	12	2	13		12	2
Dayton	(341)	54	3	57	1	54	3
Erie	(130)	15	1	17		16	1
Lehigh Valley	(325)	57	3	59	1	56	3
Mansfield	(74)	6		6		7	
Maryland	(602)	80	8	76	9	79	7
Philadelphia	(1,353)	150	13	149	15	152	15
Pittsburgh	(1,050)	151	12	143	19	151	12
Sharon	(178)	17	6	24	1	19	6
Toledo	(117)	21	1	23		21	1
Washington	(856)	90	5	89	8	93	4
West Virginia	(120)	13	1	12	3	13	1
	(6,424)	814	66	816	69	819	68
District 3							
New York	(4,884)	548	37	528	57	520	60
District 4							
Alabama	(199)	39	4	43	2	42	1
East Tennessee	(415)	50	6	43	11	52	5
Florida	(137)	16		15	1	16	
Georgia	(220)	44	5	46	4	43	4
Louisville	(115)	9		7	3	8	2
Memphis	(124)	23	1	23	1	25	1
Miami	(97)	19	1	16	3	20	
New Orleans	(246)	34		31	3	31	4
North Carolina	(229)	53	3	51	5	50	5
Oak Ridge	(115)	2		2		2	
Shreveport	(74)	7		7		7	
South Carolina	(122)	35	1	28	7	33	2
Virginia	(168)	20	4	24	2	23	3
Western Virginia	(86)	9	3	11	1	11	2
	(2,347)	360	28	347	43	363	29
District 5							
Arrowhead	(43)	7		6		6	
Central Indiana	(232)	32	1	31	2	32	1
Chicago	(1,618)	177	13	176	19	179	14
Fort Wayne	(125)	39	1	35	5	37	2
Illinois Valley	(122)	27	3	27	3	29	2
Iowa	(187)	28	1	26	1	27	2
Madison	(75)	18	2	18	3	20	2
Michigan	(805)	145	15	152	9	142	18
Milwaukee	(688)	51	10	55	5	49	11
Minnesota	(279)	40	2	37	4	39	2
Northeastern Michigan	(97)	17	1	20		18	1
Rock River Valley	(84)	12	1	13	1	11	2
South Bend	(102)	10		8	2	8	2
Urbana	(99)	17	1	18		16	2
	(4,556)	620	51	622	54	613	61
District 6							
Denver	(367)	34	2	35	2	36	
Nebraska	(108)	18	1	16	2	19	
	(475)	52	3	51	4	55	
District 7							
Arkansas	(79)	9		8		8	
Beaumont	(81)	10	1	11		10	1
Houston	(271)	27	2	24	4	26	2
Kansas City	(272)	47	1	45	2	43	4
Mexico	(216)	11		11	1	12	
New Mexico–West Texas	(148)	22	2	29		24	3
North Texas	(385)	66	7	68	3	62	9
Oklahoma City	(180)	18	2	19	2	16	4
Panhandle Plains	(131)	24	3	26		23	4
St. Louis	(521)	39		35	5	39	1
South Texas	(163)	26	2	28	1	26	2
Tulsa	(139)	17		18	1	16	2
Wichita	(82)	9	1	9		11	
	(2,668)	325	23	331	19	316	32
District 8							
Arizona	(131)	12	3	17		14	2
Los Angeles	(1,289)	137	14	142	17	134	19
San Diego	(157)	15	1	14	1	13	2
San Francisco	(1,259)	142	15	160	11	142	17
	(2,836)	306	33	333	29	303	40
District 9							
Montana	(90)	17	3	20		17	3
Portland	(438)	37	3	37	5	39	4
Richland	(94)	45	2	43	4	43	5
Seattle	(422)	68	7	73	3	69	3
Spokane	(128)	60	2	57	7	59	4
Utah	(115)	22	1	20	3	22	2
	(1,287)	249	18	250	22	249	21
District 10							
Montreal	(302)	21	1	23	2	20	2
Niagara International	(101)	15	6	23		17	5
Ottawa	(57)	3		3		3	
Toronto	(557)	42	8	51	1	43	7
Vancouver	(175)	16	1	20		17	1
	(1,192)	97	16	120	3	100	15
Section Totals	(30,673)	3,930	312	3,950	341	3,886	371
Student Members		103	3	92	8	99	7
Out of Section		29	6	35		27	5
Grand Total		4,062	321	4,077	349	4,012	383

Carthrae Merrette Laffoon

Lamme Medalist for 1949

Carthrae Merrette Laffoon (F '45), Manager of the A-C Engineering Department, Westinghouse Electric Corporation, East Pittsburgh, Pa., has been selected as Lamme Medalist for 1949 for his "outstanding contributions to the design of electric machines, particularly large turbine generators and high-frequency generators." The Lamme Medal, which has been awarded annually since 1928 by bequest of Benjamin Garver Lamme to honor achievement in



the development of electric apparatus or machinery, was presented to Mr. Laffoon during the AIEE Summer and Pacific General Meeting in Pasadena, Calif., June 12–16, 1950. The first winner of the Lamme Medal, which is shown at left, was Allan Bertram Field, and succeeding Medalists have included Edward Weston, in 1932, Vannevar Bush, in 1935, Joseph Slepian, in 1942, and David C. Prince in 1945. Last year's Medalist was V. K. Zworykin

History of the Medal

JAMES F. FAIRMAN
FELLOW AIEE

THE LAMME MEDAL was established in 1926 in accordance with the terms of the will of Benjamin Garver Lamme which provided for the award of a gold medal annually to a member of the Institute "who has shown meritorious achievement in the development of electrical apparatus or machinery." The first medal under this award was granted in 1928, and this year marks the inclusion of the name of C. M. Laffoon among 22 distinguished contributors to the development of machinery and apparatus.

Mr. Copley, in the following pages, describes the Medalist's achievements. I wish, therefore, to recount something of the significance of the medal which serves not only to honor the Medalist, but to keep before us the memory of a great engineer.

Mr. Lamme was primarily an analyst. With him the development of machinery was not a process of calculation from formulas, but rather the fruition of thoughtful reasoning processes usually so profound as to accomplish, without the mechanism of mathematical symbols, what most people could approach only through that device. To Mr. Lamme creative effort in the field of machinery and apparatus was vastly more important than any question of what organization produced the result, and certainly his interest in creative achievement went way beyond even the very broad limits of his own performance.

Beyond that, however, he was peculiarly interested in helping other engineers to grow in a personal way and to enjoy the same satisfactions that he found in his own work. Thus, it was natural that he took a keen interest in stimulating his fellow engineers, ranging from recent college graduates to that relatively small number of more mature people for whom he established the award to which the Institute has attached his name.

To ensure that the award always shall represent the kind of achievement which the donor had in mind, the Institute has constituted a committee of nine of its members confirmed by the Board of Directors and has established Bylaws requiring plural sponsorship of nominees, adequate information as to their attainments, and deliberation in consideration. Thus, you can be assured of the scrupulous care with which both Mr. Lamme's purposes and the merits of the nominees are appraised by this jury of nine of their fellow members.

Full texts of the addresses delivered during the Lamme Medal presentation ceremony at the Annual Meeting of the Institute held during the AIEE Summer and Pacific General Meeting, Pasadena, Calif., June 12–16, 1950.

James F. Fairman is Vice-President, Consolidated Edison Company of New York, Inc., New York, N. Y., and AIEE President for 1949–50.

Achievements of the Medalist

A. W. COPLEY
FELLOW AIEE

CARTHRAE MERRETTE LAFFOON was born at Coldwater, Kans., and grew up on a farm south of Kansas City. He attended country school, then three years at Warrensburg (Mo.) State Teachers College, interleaved with three years of work. He was graduated from the University of Missouri with the degree of Bachelor of Science in 1914 and received the Master's degree a year later.

Mr. Laffoon was enrolled in the graduate student course of Westinghouse Electric Corporation in 1916, and was quickly chosen as one of those privileged few who spent a year sitting across from Mr. Lamme at his desk, learning his design methods and the company's engineering prac-

A. W. Copley is Pacific Coast Engineering and Service Manager, Westinghouse Electric Corporation, San Francisco, Calif.

tices and absorbing some of the spirit of this great personality. He then started his career in a-c generator engineering as a design engineer, giving particular attention to turbogenerators. He has continued in that department, advancing to the position of Manager of A-C Generator Engineering in 1936, a position which he still holds.

As a boy Mr. Laffoon stood out among farm youngsters because of his ingenuity and his inventive abilities in devising and building labor-saving equipment for use on the farm. As a lad at country school he started winning prizes—for achievement in spelling contests. At Teachers College he was outstanding in public speaking and debate.

C. M. Laffoon

He early selected electrical engineering as his life work and planned his education accordingly. Probably the most important year of his life was that which he spent doing the "fetch and carry" work for Mr. Lamme, for there he got his basically fundamental design training. This training opened the path for him in his later work and it is quite natural that he became the leader in design.

Mr. Laffoon has directed and is in large measure responsible for the development of the rotor construction, the high-voltage insulation, the ventilation, and many other important features of the modern a-c turbogenerator. He has not confined his attention to 60-cycle generators, for he has included in his work the design of high-frequency alternators in the 5,000-cycle class.

Many patents have been issued to him covering design features of generators. He has published numerous technical articles and has presented many papers before the Institute.

C. M. Laffoon became an Associate of the AIEE in 1924 and a Fellow in 1945. He served as Director from 1942 to 1947.

The Progress of Engineering Design

C. M. LAFFOON
FELLOW AIEE

IT IS an honor to receive an engineering achievement award from the AIEE. It is an outstanding honor to me to receive the Benjamin Garver Lamme Medal because of my close association with him during the last several years of his life, and I accept the Lamme Medal for 1949 with deep feelings of appreciation, humility, and humbleness, and a full realization that its acceptance imposes great responsibilities. I am also mindful of the fact that under present-day conditions my meager engineering accomplishments in generator design have been greatly augmented by the loyal co-operation and assistance of engineering associates, engineers of other departments, and the encouragement and financial support of the Westinghouse Electric Corporation.

When I was graduated from the University of Missouri, in 1915, I was confronted with two major problems: one to decide on the kind of electrical engineering work to undertake; and the other, to obtain a job. At that time both were rather difficult. In common with most engineering students, much thought was given to the question of choice of kind of work. As graduation approached I had convinced myself that I did not want engineering design. However, during the last few weeks of my senior year the Engineering Department Librarian gave me a copy of an article entitled "Physical Concepts of the Problems of Commutation in Direct Current Machines" by B. G. Lamme, at that time Chief Engineer of the Westinghouse company.

Although I had never been particularly interested in d-c machines, I did become greatly interested in Mr. Lamme's method of approach and physical interpretation of this rather complicated problem. It was this article by a prominent man of whom I had never heard before, in conjunction with advice from a former classmate that Mr. Lamme took a personal interest in training engineers for design work, that cleared away my prejudice against engineering design. I can bear witness to the fact that the choice of my life work was influenced and determined by the ideals and accomplishments of this outstanding engineer.

As the years pass by and the time gap widens between us and illustrious engineers who have passed on, we can review their work and legacies with a clearer perspective. Undoubtedly the greatest heritage passed on by Mr. Lamme was the knowledge, appreciation of engineering, and the inspiration he gave to a host of young engineers and associates. As a result, his ideals and his basic knowledge of design engineering problems and their solution were spread and amplified manyfold. He was cognizant of this situation, for he once said, "In my 35 years of work with the Westinghouse company, I have seen many young men grow from pupils to assistants and associates. This has been one of my greatest pleasures. I have aimed to instill

C. M. Laffoon is Manager of the A-C Engineering Department, Westinghouse Electric Corporation, East Pittsburgh, Pa.

in them engineering honesty and honor, square dealing, and fair fighting—that there should be pride in accomplishment and that true engineering means much more than merely making a living—that it means the advancement of the art for the benefit of mankind." The influence of a man with a philosophy of life of this caliber can be none other than good and lasting.

Orderly and reasonably rapid engineering progress results from a dynamic rather than a static type of philosophy. The rate of progress in engineering design is greatly impeded in many instances by the human inertia coefficient of self-complacency. Twenty-five years ago some engineers thought that the ultimate had been reached in building generators for the production of electric power. At that time a 22,500-kva 3,600-rpm generator was the largest rating built or seriously contemplated at this speed. The introduction of hydrogen as the cooling medium, with its vastly improved thermal and heat transfer coefficients, opened new avenues for building larger ratings with material improvements in efficiency. During a short span of 15 years, the maximum rating of 3,600-rpm generators has been increased severalfold. Single-unit generators at this speed are now being built at ratings of 150,000 kva, and ratings up to 175,000 kva are currently available. It is anticipated that 3,600-rpm single-shaft generators for ratings up to 225,000 kva will be available when the need arises for such units.

The solution to some of the design and construction problems of turbine generators has required an appreciable amount of time because a long operating period usually elapses before the difficulty develops to the point of detection. Further time is then needed to observe the conditions, analyze the data and develop the mechanism of failure, and find a remedy. In many instances, the corrective means follow a thorough research investigation in the characteristics of the materials in use. Appreciable time, and the co-operative effort of research, electrical, mechanical, and insulation engineers, were required to obtain satisfactory solutions to the generator problems of corona elimination, rotor conductor deformation, elimination of double-frequency rotor vibration, and flexible mounting for the stator cores of 2-pole 3,600-rpm turbine generators. The new "Thermalastic" high-voltage insulation which has sufficient strength and elastic properties to withstand the expansion and compression forces resulting from the differential expansion of the stator conductors and the stator iron was developed with the same kind of co-operative effort.

Although the generation of electric power has advanced to high standards of performance, ultimate goals have not been reached. With the changing economic condition there is a need for an expanding use of low-cost electric power. The numerous new or improved materials already available greatly widen the designer's horizon and offer almost unlimited opportunities for advancement in the design and construction of a-c generating equipment. On the basis of forward-looking programs now under way and contemplated, the greatest possibilities for increasing the output per unit of materials and thus reducing power production costs is to be expected from new insulation materials, improved methods of ventilation, and the use of new cooling media. We have now reached the threshold where developments of tremendous importance can be expected at any time. If we continue to move forward with confidence, perseverance, and faith in ourselves, our government, and our people, adequate generating equipment can and will be made available for economically producing sufficient electric power to meet our increasing standards of living.

I am glad to have had the opportunity of being associated with an industry which is so vitally related to the economic welfare of the United States and the entire world. It has been a privilege and a pleasure to work with associates and fellow engineers in the various phases of this vast enterprise. And, I am honored to be a member of the American Institute of Electrical Engineers.

Fluorescence Detector-Comparator

A recent development of Menlo Research Laboratory, Menlo Park, Calif., permits the application of ultraviolet light for materials testing, criminology, and medical diagnosis without the limitations imposed by power lines, heavy batteries, and high ambient light levels. The instrument, called a Fluoretor, is illustrated at the left in use on a routine laboratory comparison. The specimens being examined are enclosed within the light-tight cylindrical housing in the technician's left hand. A complete self-contained power supply is housed in the barrel of the handle which is attached by a knuckle joint to the light-source and filter housing. The specimens are studied under a 3-power magnifying eyepiece which slides in and out for focussing.

The Measurement of Impulse Voltages by Repeated-Structure Networks

C. L. DAWES
FELLOW AIEE

C. H. THOMAS
ASSOCIATE AIEE

A. B. DROUGHT
STUDENT MEMBER AIEE

Theory has shown that a certain repeated-structure voltage divider will give ideal measurements of surge voltages at all frequencies and wave forms. This article discusses a number of these repeated-structure networks and shows what sort of results may be expected with their use.

THE ACCURATE measurement and recording of the impulse voltages used in the surge testing of dielectrics and electric apparatus is of great importance. The methods of measurement used in the past are attended by fundamental errors the magnitudes of which are not easily ascertained, especially for waves having very steep fronts. The recognition of the presence of these errors[2,4–6] warrants a completely new approach to the problem of designing high-voltage dividers.

In the original paper[1] it is shown by rigorous analysis that certain types of repeated-structure networks are ideal for surge-voltage measurements at all frequencies and wave forms. Repeated-structure prototype voltage dividers, constructed in accordance with the theoretical design, have been investigated experimentally, and the laboratory tests not only substantiated the analytical theory but indicated that much greater accuracy than has heretofore been obtainable is now possible.

F. M. Defandorf has summarized the methods of high-voltage measurement.[2] Of the various methods described the potential divider is widely used for the measurement of impulse voltage. Present voltage dividers may be divided into four groups, corona-shielded resistor, surge resistor, capacitor divider, and capacitance-shielded and guarded resistor.

The corona-shielded resistor tends to increase stray capacitance and for this reason is undesirable. At the present time the surge-resistor type of divider shown in Figure 1 is commonly used. This consists of a large number of bifilar-wound resistors all connected in series. A voltage tap across a portion R_a of the grounded end of the resistor is connected to another voltage divider R_b, usually through a considerable length of shielded cable. The cathode-ray oscillograph is connected to the tap of the voltage divider R_b. This arrangement is identical with that shown in Figure 1 of reference 3.

It is apparent from previous investigations[4–6] that a surge-resistor divider cannot be represented as a lumped pure resistance parameter. Since it is not a pure resistance, errors in the reproduction of wave forms may be expected. A surge-resistor divider can be more accurately represented by the circuit in Figure 2 where R_g is the leakage resistance to ground, R is the series resistance, C_s is the shunting capacitance between turns, C_p is the parallel capacitance to ground, and L is the series inductance. Marius Böchman and Nils Hylten-Cavallius[5] presented an analysis of the errors introduced by the component elements each considered separately, but they did not determine the combined errors.

In an attempt to minimize the effect of inductance and extraneous capacitance the capacitor type of divider[2] is sometimes used. Since the high-voltage capacitor usually consists of spheres with large spacings, the capacitances to ground are large and it is difficult to compute the divider ratio. J. H. Hagenguth points out that it has often been necessary to calibrate capacitor dividers with an auxiliary resistor divider. Furthermore, it is difficult to connect the cathode-ray oscillograph to the divider without reflections, which greatly impairs the accuracy.

In the capacitance-shielded and guarded resistor type of divider capacitance shielding has been accomplished in two ways: Höhl[7] placed a capacitor and resistor divider in parallel and made the time constants of the two sections thus formed identical; the Allmanna Svenska Elektriska Aktiebolaget[5] investigated the divider with a screen, sometimes

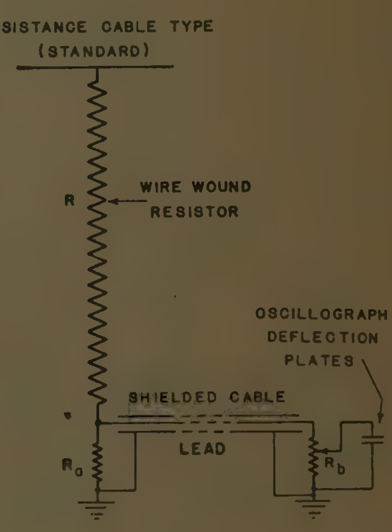


Figure 1. Surge-resistor type of voltage divider

Resistor R consists of a large number of bifilar-wound resistors connected in series

Condensation of paper 50-89, "Impulse Measurements by Repeated-Structure Networks," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1950. Scheduled for publication in *AIEE Transactions*, volume 69, 1950.

C. L. Dawes and **C. H. Thomas** are with Harvard University, Cambridge, Mass., and **A. B. Drought** is with Marquette University, Milwaukee, Wis.

The authors thank J. H. Hagenguth of the General Electric Company, Pittsfield, Mass., for suggesting the voltage divider as a problem for this research performed in partial fulfillment for the degree of Doctor of Science by A. B. Drought. They appreciate the loan by Mr. Hagenguth of a wire-wound resistor card which became the basic unit in the surge-resistor type of divider which was constructed. They are indebted to P. L. Bellaschi who followed the research closely and made valuable suggestions.

termed a "doughnut" or a "pie-plate," on the upper end of the divider. Either of these methods seem to eliminate the undesirable effects of the capacitance to ground. If one considers the response of such a compensated divider without the cable lead, however, it is found to be limited in accuracy by the series inductance. The uncompensated surge-resistor divider may be nearly as satisfactory if careful attention is given to the spacing of the equipment in the laboratory. The ASEA also added a nonlinear resistive element around the measuring resistor to equalize the nonlinearity of the capacitance voltage distribution. It would seem that such a resistance would tend to increase the inductance.

In all the types of dividers described in the foregoing paragraphs attempt has been made to reduce the errors either by making the error-producing parameters such as linear inductance and capacitance, and resistance and capacitance to ground, as small as possible, or by some form of shielding. It is doubtful if any of these methods can be made to give the required accuracy with very short impulses. Furthermore, the cable lead is still part of the circuit and cannot form a proper termination under all conditions, and hence must contribute to the over-all error.

It can be shown by transient analyses that a simple network made up of equal T (or π) sections, Figure 3, will produce a divider which will attenuate equally all frequencies without change in phase and consequently will reproduce accurately any wave form, whatsoever, with the desired attenuation. By making the impedance of the terminating network, of which the cathode-ray oscillograph is a part, equal to the surge impedance of the network, the input wave form will be reproduced accurately at the terminals of the oscillograph.

In Table I are shown six possible T sections, each of which may form the units of the divider in Figure 3. Also, the restrictions among the network parameters and the parameters of the terminating network for each T section are given. Several dividers, made up of these different T sections, were constructed and tested.

A prototype divider consisting of three T sections, network A, Table I, was first constructed. Each branch of the T was composed of a special carbon-type resistor of 10,000 ohms ±1 per cent, in parallel with a capacitor of 90 micromicrofarads, ±0.5 micromicrofarad. The resistive element in the termination was adjusted to a value of 17,350 ohms (R_0, Table I). The capacitive element in the termination consisted of the vertical plates of a cathode-ray tube, the input capacitance to a vacuum-tube voltmeter, and a variable air capacitor all connected in parallel. The total capacitance was adjusted to 52 micromicrofarads (C_0, Table I).

This prototype divider was tested by measuring the output and input voltages, $E(j\omega,N)$ and $E(j\omega,0)$ respectively, Figure 4, by means of two vacuum-tube voltmeters, over the frequency range of from zero to five megacycles per second. Measurements were made on each of the three sections separately, then on two sections in cascade, and finally on all three sections in series. A plot of the ratio of input to output voltage as a function of frequency for a single section is shown in Figure 5. Curve 1 was obtained with the shunt resistor of the termination having the resistance equal to that of R_0, and the shunt capacitance equal to C_0, the values which give a constant ratio of input to output voltage and zero phase displacement between these voltages. It will be noted that the ratio remains constant over the entire frequency range. The results of measurements on two and three sections in cascade were similar to those obtained with one. The ratio $E(j\omega,0)/E(j\omega,N)$ remained constant within ±2 per cent from zero to five megacycles per second, the ratios then being 13.93 for two sections and 52 for three sections.

The effect of detuning the terminating impedance is also shown in Figure 5. With too little capacitance, the voltage

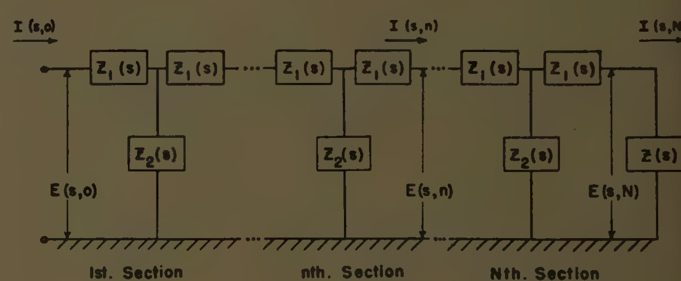


Figure 3. Repeated-structure network composed of T sections which will reproduce any wave form accurately with any desired attenuation

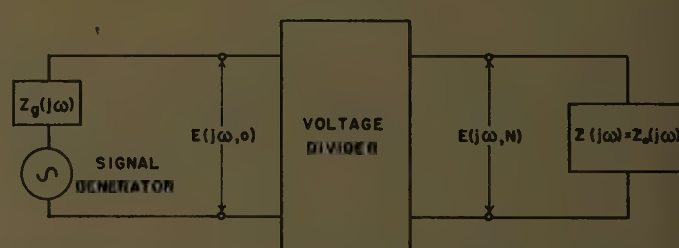


Figure 4. Test circuit for measuring the voltage-divider frequency response of network A shown in Table I

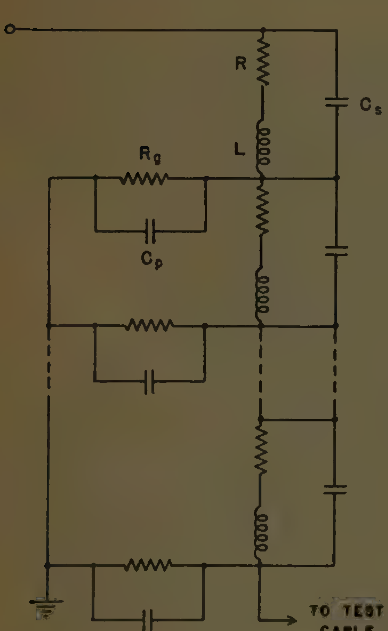


Figure 2. Equivalent circuit of a surge-resistor divider

R_g = leakage resistance to ground
R = series resistance
C_s = shunt capacitance between turns
C_p = parallel capacitance between turns
L = series inductance

ratio decreased at high frequencies as shown in curve 2; and with too much capacitance the voltage ratio increased at high frequencies; see curve 3. Detuning the terminating capacitor by ten micromicrofarads had no significant effect on the voltage ratio over the frequency range from zero to five megacycles per second; however, a slight phase shift became noticeable at five megacycles, as shown in Figure 7*A*.

Oscillograms were taken at the same time the measurement of the voltage ratio was made on the divider. The input voltage $E(j\omega,0)$ was applied to the horizontal plates

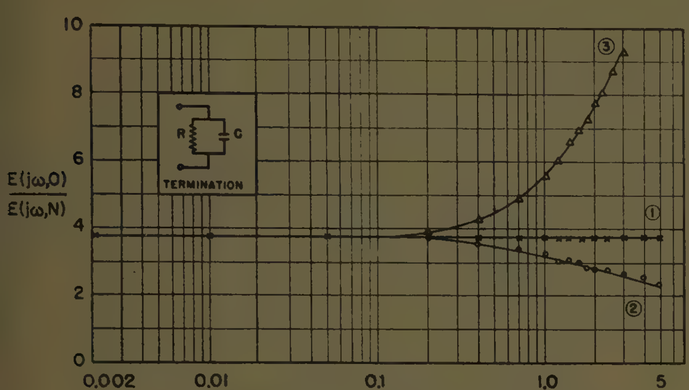


Figure 5. Frequency response of one section of network *A* shown in Table I

1. $R=R_0$; $C=C_0$ *2.* $R=R_0$; $C \ll C_0$ *3.* $R=R_0$; $C \gg C_0$

and the output voltage $E(j\omega,N)$ was applied to the vertical plates of a cathode-ray tube. The resulting pattern was a Lissajous figure which was a straight line when both voltages were in time phase. Oscillograms were taken for one, two, and three sections, but oscillograms are shown for one section only, since with more than one section the ratio was so great that only a small vertical deflection could be obtained.

Photographs of Lissajous figures were taken at frequencies of 200 kc, one megacycle, and five megacycles per second and are shown in Figures 6*A*, *B*, and *C* respectively. No evidence of phase shift is observable. Figures 6*D*, *E*, and *F* are photographs of Lissajous figures taken with the same test circuit and at the same frequencies but with the type-*A* voltage divider replaced by a surge-resistor divider of the conventional type. For this conventional divider considerable phase shift above one megacycle per second is present. In addition, the attenuation increased by a significant amount at the higher frequencies.

Figures 7*A*, *B*, and *C* show the effect of improper termination of a single section of the type-*A* divider. Reference has already been made to *A* in which the terminating impedance was detuned by a change of ten micromicrofarads in the capacitance. In *B*, at one megacycle per second no terminating capacitance is present except that of the vertical plates of the cathode-ray tube, and in *C*, also taken at one megacycle per second, the termination is 200 micromicrofarads rather than the critical value of 52 micromicrofarads. The phase shifts in *A*, *B*, and *C* show the importance of proper termination of the network. Dividers of the type shown by *B*, *C*, *E*, Table I, were constructed and tested with the cathode-ray oscillograph and vacuum-tube voltmeter as the termination. It was impossible to obtain constant ratio and zero phase displacement since the equivalent circuit of the terminating instruments consisted of resist-

TABLE I

T-SECTION NETWORKS

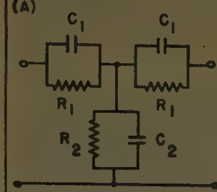
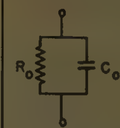
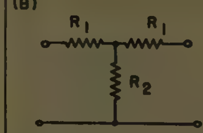
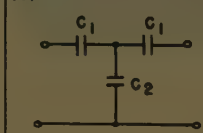
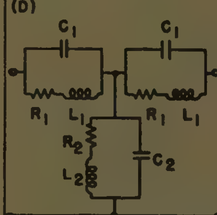
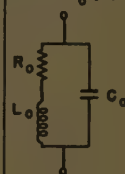
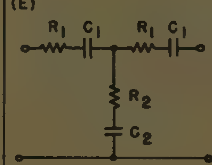
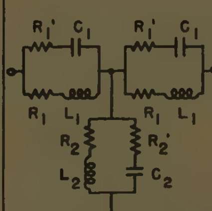
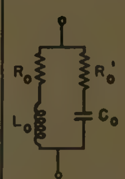
TYPE	RESTRICTIONS	CHARACTERISTIC IMPEDANCE
(A) 	$R_1C_1=R_2C_2$	 $Z_0(s)=\frac{R_0}{R_0C_0s+1}$; $R_0=R_2\sqrt{\lambda^2-1}$; $C_0=\frac{C_2}{\sqrt{\lambda^2-1}}$; $\lambda=\frac{R_1+R_2}{R_2}=\frac{C_1+C_2}{C_1}$
(B) 	NONE	 $Z_0(s)=R_0$; $R_0=R_2\sqrt{\lambda^2-1}$; $\lambda=\frac{R_1+R_2}{R_2}$
(C) 	NONE	 $Z_0(s)=\frac{1}{C_0s}$; $C_0=\frac{C_2}{\sqrt{\lambda^2-1}}$; $\lambda=\frac{C_1+C_2}{C_1}$
(D) 	$R_1C_1=R_2C_2$; $\frac{L_1}{R_1}=\frac{L_2}{R_2}$	 $Z_0(s)=\frac{L_0s+R_0}{L_0C_0s^2+R_0C_0s+1}$; $R_0=R_2\sqrt{\lambda^2-1}$; $L_0=L_2\sqrt{\lambda^2-1}$; $C_0=\frac{C_2}{\sqrt{\lambda^2-1}}$; $\lambda=\frac{R_1+R_2}{R_2}=\frac{L_1+L_2}{L_2}=\frac{C_1+C_2}{C_1}$
(E) 	$R_1C_1=R_2C_2$	 $Z_0(s)=R_0+\frac{1}{C_0s}$; $R_0=R_2\sqrt{\lambda^2-1}$; $C_0=\frac{C_2}{\sqrt{\lambda^2-1}}$; $\lambda=\frac{R_1+R_2}{R_2}=\frac{C_1+C_2}{C_1}$
(F) 	$\frac{R_1'}{R_1}=\frac{R_2'}{R_2}$; $R_1'C_1=R_2'C_2$; $\frac{L_1}{R_1}=\frac{L_2}{R_2}$	 $Z_0(s)=\frac{(L_0s+R_0)(R_0'C_0s+1)}{C_0s(L_0s+R_0)\quad R_0'C_0s+1}$; $R_0=R_2\sqrt{\lambda^2-1}$; $R_0'=R_2'\sqrt{\lambda^2-1}$; $L_0=L_2\sqrt{\lambda^2-1}$; $C_0=\frac{C_2}{\sqrt{\lambda^2-1}}$; $\lambda=\frac{R_1+R_2}{R_2}=\frac{R_1'+R_2'}{R_2'}=\frac{L_1+L_2}{L_2}=\frac{C_1+C_2}{C_1}$

Table I. Restrictions and terminations for six networks

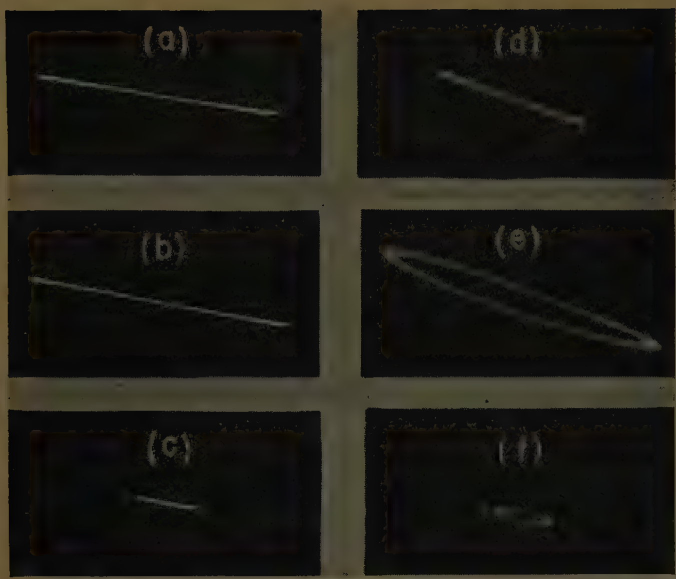


Figure 6. Lissajous figures

A—Network A, Table I, at 200 kc
B—Network A, Table I, at one megacycle
C—Network A, Table I, at five megacycles
D—Surge-resistor divider, 200 kc
E—Surge-resistor divider, one megacycle
F—Surge-resistor divider, five megacycles

ance and capacitance in parallel. This is illustrated by Figure 7*D* which shows the phase shift in a type-*B* network that had correct resistance termination, but the small capacitance of the deflection plates of the cathode-ray oscillograph not only caused phase shift but also produced a variable ratio similar to that given by curve 3, Figure 5, for which the terminating capacitance was too large. Since the type-*D* network, however, contains shunted-capacitance elements, it was possible to obtain correct termination with the cathode-ray oscillograph as is shown by Figures 7*E* and *F*. Type-*F* network can be made to give correct results provided R_2' is relatively small compared to the other circuit constants present.

The type-*A* divider, Table I, was tested for transient response. The output terminals of a wave-shaping impulse circuit were connected to the input terminals of the divider. The sweep in each case was carefully calibrated and could be measured accurately to about 0.2 microsecond. Figures 8*A* and *B* show oscillograms taken of input voltage $e(t,0)$ and output voltage $e(t,N)$ for correct termination. Figures 8*C* and *D* show oscillograms taken of the output voltage for incorrect termination. When the network is incorrectly terminated, the output wave shape is far from being a reproduction of the input wave.

In order to obtain photographs with a relatively fast sweep, an impulse was switched repeatedly on to the voltage-divider terminals of the type-*D* network and photographs made of the input and output voltages. The cathode-ray-oscilloscope sweep, exponential in form, was initiated by a mercury switch. In Figure 9 are oscillograms of input and output voltages where the divider consisted of one section of the network of type-*D*, Table I. No deviation of output from that of the input is observable in these illustrations.

LARGE-SCALE MODEL

A LARGER model capable of measuring up to 50,000 volts peak was constructed. This supposedly was a network of type-*A*, Table I, consisting of a single section in which the impedances $Z_1(s)$ and $Z_2(s)$, Figure 3, were made identical. The resistive elements consisted of the 1,000-ohm noninductive resistors which had been used for the surge-resistor divider described earlier in the article. The inductance of each 500-ohm card was less than three microhenrys. Pin-type suspension insulators were used for the capacitor units. The capacitance of each of a number of insulators was measured and those selected for the divider had a capacitance of 39 micromicrofarads, ±0.5 micromicrofarad.

A frequency response test was made, as was done with the prototype dividers, and the results were unsatisfactory. It was found that the length of leads was extremely critical. It was found possible, however, to obtain satisfactory results if the lengths of the leads in each section element were made identical. The 1,000-ohm essentially noninductive resistors were then replaced by some wire-wound ceramic-coated resistors, which had an over-all length of about 15 inches and a resistance of 20,000 ohms plus appreciable inductance. With these resistive-inductive elements the results were excellent. The voltage ratio was constant with frequency, and no phase shift was detectable.

When the noninductive resistors were used, the inductance of the leads was appreciable and the divider was thus of the type *D* rather than of type *A*. Since the inductance

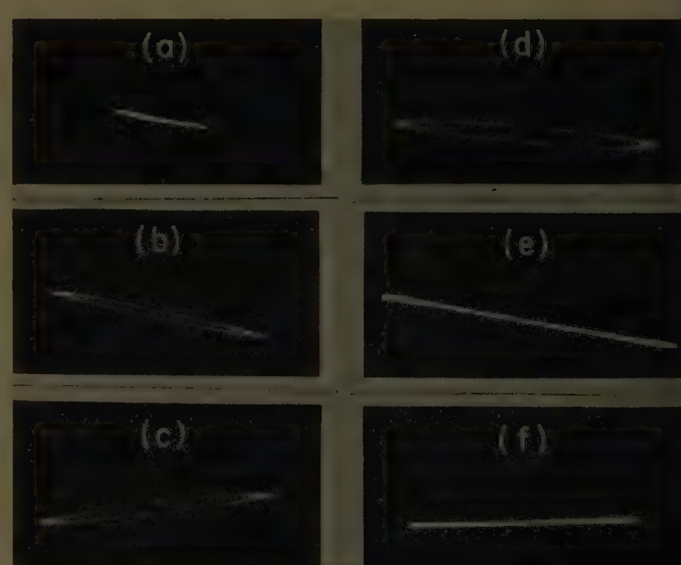


Figure 7. Lissajous figures

A—Network A, Table I, at five megacycles with the terminating capacitor detuned by ten micromicrofarads
B—Network A, Table I, at one megacycle with the terminating capacitor much less than the required value
C—Network A, Table I, at one megacycle with the terminating capacitor much greater than required value
D—Network B, Table I, at one megacycle with the correct resistance termination
E—Network D, Table I, at one megacycle with the correct termination
F—Large-scale model (network D, Table I), at one megacycle with correct termination and an attenuation of 22

of the leads was more or less indeterminate; it was difficult to obtain the correct values of L_1 and L_2 for the type-D divider of Table I. However, the inductance of the ceramic-coated resistor units was large compared with the inductances of the leads, and since the inductances of the units were essentially equal, the type-D divider was readily produced and improvement in performance resulted. This, we believe, emphasizes one advantage of the network-type divider; that is, the stray inductances of the leads need not in any manner vitiate the ideal characteristics of the divider.

Means for adjusting the voltage ratio of a network divider has not been explicitly considered in this article; however, there are a number of ways in which a variable attenuation may be obtained on a given divider. In order to test this large-scale model more completely, both a cold-cathode type of oscillograph and a glass-tube type, each with a very fast sweep that can be synchronized with the surge generator, are needed. With instruments of this type the model can be tested with impulses of very short duration, and the input and output can be computed accurately. Experimental work is being conducted at the present time on this aspect of the problem.

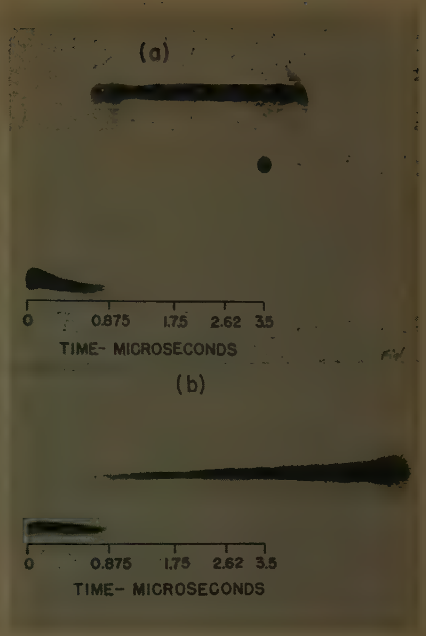


Figure 9. Oscillograms of (*A*) input and (*B*) output voltages of a divider of one section of network *D* of Table I

CONCLUSIONS

THE following conclusions can be reached concerning these dividers:

1. The repeated-structure network described in this article has been shown by rigorous analysis to possess the ideal characteristics of an attenuating network for passing any kind of signal whatsoever without distortion. Experimental results from tests made on the simple T structure are sufficiently favorable to indicate that a practical improved high-voltage divider of high accuracy may be constructed. When a cathode-ray oscilloscope is used as the indicating instrument and its input impedance becomes a part of the terminating impedance, networks of type A, D, and possibly C and F are particularly suitable.

2. The impedances of the leads can be included in the required impedances of the arms of the network.

3. The effect of stray capacitance to ground can either be compensated for or made negligible by proper choice of the circuit parameters in the networks of Type A, C, or D in Table I.

4. In the repeated-structure network type of voltage divider, the presence of inductance as part of the resistive elements may be desirable; stray capacitance may be either compensated or neglected; and the input capacitance to the cathode-ray tube may be incorporated as part of the terminating impedance.

5. The need for a cable lead to the measuring instrument is eliminated.

6. With the theory completely presented, the authors have considered the practicability of a divider for very high voltage, 1,000,000 volts and higher, and believe that such a divider is practicable.

Figure 8. Oscillograms for one section of network *A* of Table I

A—*Input voltage, $e(t, 0)$*
B—*Output voltage, $e(t, N)$, with the correct network termination*
C—*Output voltage, $e(t, N)$, with $R=R_0$ and $C \ll C_0$*
D—*Output voltage, $e(t, N)$, with $R=R_0$ and $C \gg C_0$*

REFERENCES

1. Impulse Measurements by Repeated-Structure Networks, C. L. Dawes, C. H. Thomas, A. B. Drought. *AIEE Transactions*, volume 69, 1950 (*Proceedings T089*).

2. The Measurement of High Voltage, Francis M. Defandorf. *Journal*, Washington Academy of Sciences (Menasha, Wis.), volume 38, number 2, February 13, 1948, pages 33–60.

3. American Standards for Measurement of Test Voltage in Dielectric Tests. AIEE *Standards, Number 4*, March 1943, pages 1–23.

4. Short-Time Spark-Over of Gaps, J. H. Hagenguth. AIEE *Transactions*, volume 56, 1937, pages 67–76.

5. Errors in Measuring Surge Voltages by Oscillograph, Marius Böchman, Nils Hylten-Cavallius. *ASEA Journal*, number 7084E, March 1946, pages 1–16.

6. The Measurement of High-Surge Voltages, P. L. Bellaschi. AIEE *Transactions*, volume 52, June 1933, pages 544–52.

7. Der Hochspannungteiler beim Kathodenstrahloszillographen, H. Höhl. *Archiv fuer Electrotechnik* (Berlin, Germany), volume 36, 1942, pages 329–31.

8. Transients in Linear Systems (book), M. F. Gardner, J. L. Barnes. John Wiley and Sons, Inc., New York, N. Y., 1942.

9. Single-Layer Coil Under Electrical Impacts, Karl Lerstrup. Thesis, Graduate School of Engineering, Harvard University, Cambridge, Mass., 1942.

Planning a 13,800-Volt Subtransmission System

R. W. BROWN
ASSOCIATE AIEE

SYSTEM STUDIES are generally thought to be the engineering analysis and planning that are done in connection with the operation and expansion of large transmission or interconnected power systems. Distribution systems, particularly systems serving rural areas, often develop haphazardly in response to requests for service from prospective customers with little or no thought being given to over-all planning for the system. The system to be described developed in this manner until an increasing number of complaints of poor service from the customers being served made it obvious that some study would have to be given the system.

The area is served by a 13,800-volt subtransmission system supplied with power from a 69,000/13,800-volt substation at the center of the load area. The subtransmission system serves nine communities and many miles of 2,400-volt delta and 4,160-volt Y rural line. An increasing number of customer complaints directed attention to these rural feeders in late 1945. An analysis of the complaints, together with a study of load and voltage data obtained at various points on the rural distribution systems, indicated that three areas were suffering from very bad service.

Two of these areas, designated as the Waconia and the Hamburg rural groups, were served by long single-phase feeders operating at 2,400 volts. The Waconia group is served from the urban distribution system of the town of Waconia. Four separate plans were developed for improving service on this feeder. The plan adopted required that the single-phase feeder be rebuilt as a 3-phase circuit. Individual customers are located along this feeder so that the load is evenly distributed between phases along the line. The Hamburg group is served from a 75-kva 3-phase 13,800/4,160-volt Y rural distribution substation. The major portion of the load was served by a long single-phase feeder.

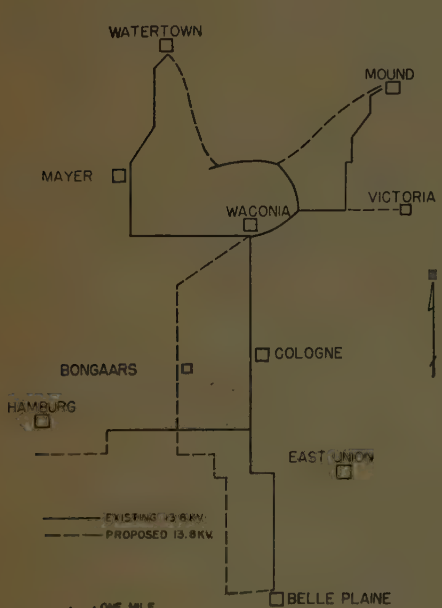


Figure 1. Single-line diagram of 13,800-volt subtransmission system. Solid lines indicate the existing system. Dashed lines indicate new 13.8-kv lines to be constructed

Study of the system indicated that by building a short section of 3-phase line the single-phase feeder could be divided into three shorter feeders of equal load, and these could be reconnected to balance the load on the 3-phase system. It was also determined that it would be necessary to relocate the substation serving the system from its present location at one edge of the load area to a point at the load center if satisfactory service were to be rendered in the future. This relocation requires moving the substation $4^1/_2$ miles and building the necessary 13,800-volt line to supply it.

The third area involved is known as the Cologne rural group. This system is a 3-phase 4,160-volt Y line served from the Cologne distribution substation bus. The 3-phase feeder extended 13 miles from the source at Cologne, and two 2,400-volt single-phase feeders each extended another six miles beyond the end of the 3-phase line.

A large creamery located at Bongaards, ten miles from Cologne and served from the rural system, notified the company that they planned to triple their load. This expansion would nearly double the load on the distribution system, which was already suffering from excessive voltage drop during peak load periods.

Four different plans for improving service on the system were developed. The plan adopted required construction of a 13,800/4,160-volt Y distribution substation to serve the outlying portion of the system. This station was located at the end of the existing 3-phase feeder, about three miles from the creamery load. The original system was divided so that about 60 per cent of the load was transferred to the new station.

The studies of the rural systems as outlined herein indicated that in addition to improving them, the 13,800-volt subtransmission system also needed bolstering up. It was decided to retain the transmission system at 13,800 volts and to increase its capacity by building additional 13,800-volt lines of sufficient capacity so that both the existing line and the new line, operated together, could handle double the existing load on the system. The system was developed so that the additional 13,800-volt lines will also provide 2-way feed to each of the major distribution substations on the system.

A standard distribution substation was designed for use on the system. All of the distribution substations now in service on the system need major rebuilding and will be rebuilt to conform to the standard station which will provide voltage regulation and adequate fault protection.

Digest of paper **50-124**, "Future Planning for a 13,800-Volt Subtransmission System and Associated Rural Distribution Systems," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Great Lakes District Meeting, Jackson, Mich., May 11–12, 1950. Not scheduled for publication in AIEE *Transactions*.

R. W. Brown is with the Interstate Power Company, Dubuque, Iowa.

The Number 5 Crossbar Dial Telephone Switching System

F. A. KORN
MEMBER AIEE

JAMES G. FERGUSON
MEMBER AIEE

The Number 5 Crossbar System is the newest switching system to be installed for use with dial telephones. It is capable of operation with all present local, tandem, and toll switching systems. It can be used for as few as four digits in a subscriber number, or as many as 11 digits may be used to code the called subscriber completely

THE Number 1 Crossbar System, predecessor of the Number 5 System, was described to the AIEE in a paper presented by F. J. Scudder and J. N. Reynolds[1] of the Bell Telephone Laboratories about ten years ago. This crossbar dial telephone switching system, which was then just being introduced in the Bell System, was designed for large cities where the panel system had been used for almost 20 years. Since then approximately 350 crossbar dial offices of this type, serving nearly 5,500,000 subscriber stations, have been installed in the larger cities throughout the United States. During these years improvements have been made in the Number 1 Crossbar System to make it more serviceable to the telephone user and to meet the new problems which have arisen.

Bell Telephone Laboratories' engineers have continued their searches for new and better telephone switching systems. One such search was for a dial system which would better meet the telephone switching requirements for areas on the outskirts of metropolitan cities and at the same time care for medium- to large-sized offices in other areas. Work on this problem culminated in the development of the new Number 5 Crossbar System, and on July 11, 1948, the first office of this type was placed in service at Media, Pa., a suburb of Philadelphia.

The field of application of this new switching system is more extensive than that of any previously developed. The Number 5 System is capable of operating with all present local, tandem, and toll switching systems of the Bell System and of the independent companies which connect with it. In addition, it can serve as a tandem or toll-center switching office where this is advantageous. It can be readily equipped with features for operation as required at toll centers for nation-wide operator toll dialing and also for automatic message accounting,[2] which permits subscriber dialing to be extended to considerable distances. Number 5 Crossbar is designed for operation with as few as four digits in a subscriber number, or it can complete calls which require as many as 11 digits, (dialed by operators) three for the national area code,[3] three for the office code, four for the numericals, and the last for the station letter of the called number on certain types of party-line service.

The Number 5 Crossbar System is like the Number 1 System in the following ways:

1. It is essentially a relay system employing simple forms of relays and relay-type structures for all switching operations. The apparatus consists largely of crossbar switches, multicontact relays, and smaller relays similar to those generally employed in all telephone switching systems.
2. Primary-secondary groupings of crossbar switches tunnel the traffic from lines to trunks and trunks to lines.
3. Utmost freedom of action in routing each call is provided by components which transfer all control over switching sequences from the subscriber's dial to circuit elements in the office.
4. The register, sender, and translator elements are employed for only a short time in each connection; thus small groups of them serve large groups of lines. Each element is brought into a connection for only the interval required to perform its function.
5. Control over practically all switching and pulsing operations is centered in groups of circuit elements called markers. They perform so quickly that a few of them will handle all calls in an office.
6. Advantage is taken of secondary benefits from common control operation including automatic alternate routing, second trial, and automatic trouble detection.

Number 5 Crossbar differs materially from Number 1 in the following things:

1. Switching plan.
2. Trunking arrangements.
3. Utilization of new items of apparatus.
4. Equipment design.
5. Circuit operation.
6. Maintenance provisions.

This combination of innovations gives Number 5 unusual versatility with standardization while the extended use of the common control principle and the introduction of new maintenance concepts endow the new system with other important features, a few of which are discussed here.

SWITCHING PLAN

The Number 5 Crossbar System is different from Number 1 primarily in its switching plan, a simple block diagram of

Essentially full text of paper 50-41, "The Number 5 Crossbar Dial Telephone Switching System," recommended by the AIEE Committee on Communication Switching Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

F. A. Korn and James G. Ferguson are with Bell Telephone Laboratories, Inc., New York, N.Y.

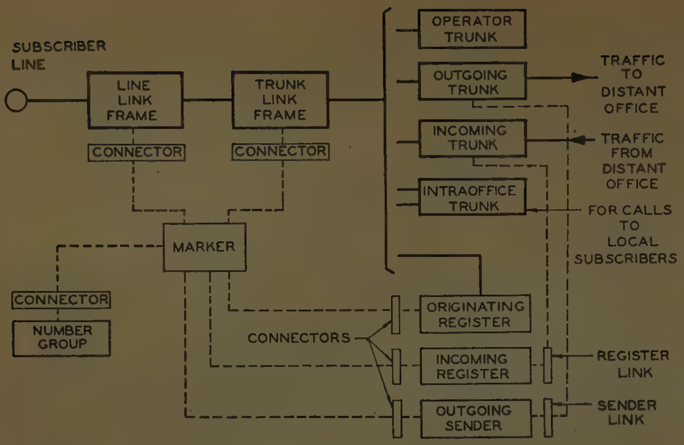


Figure 1. Basic arrangement of the switching plan of the Number 5 Crossbar System. Every subscriber line appears on one of the line-link frames, and all trunk and originating register circuits appear on the trunk-link frames

which is shown in Figure 1. Each subscriber line appears on one of the line-link frames and all trunk and originating register circuits on trunk-link frames. As in the case of Number 1, the line has but a single appearance on the line-link frame, and this serves for both originating and terminating calls. Every connection is set up from a trunk or a register to a calling or a called line through crossbar switches on trunk-link and on line-link frames. The common control equipment which is used to set up the various connections includes the markers, the connectors, the number groups, the senders and registers, and the sender and register links. Once a talking path is established, all control elements are released and only the line-link, trunk-link, and trunk circuit elements remain in the connection.

Before any talking path is set up, all needed information on calling and called parties is registered in a way which enables a marker in a uniform and flexible manner to call into the connection only those switching, signaling, transmission, and supervisory features required for the particular call. On every subscriber call, the calling line, through a connector, engages a marker to connect the calling line temporarily to an originating register through crossbar switches of the line-link and trunk-link frames after which the connector and marker are released. When all of the needed information on calling and called parties is stored in the originating register, a marker is again engaged for a fraction of a second to establish the talking connection. Knowing both ends of the connection required and with no switching equipment committed, the marker is free to set up any kind of a call with the best combination of elements.

If the call is to another subscriber in the same office, the marker connects an idle intraoffice trunk circuit to the calling and called lines.

If the call is to a destination outside the office, the marker recognizes this from the information dialed and proceeds to connect the calling line to a trunk circuit in the proper group. If a sender is needed, the marker connects one of the appropriate type to the trunk circuit through a sender link. Senders receive information from the marker and transmit it in the form of pulses to registers, other senders, or directly to switches as required in the systems of the connecting offices. This information may be the called subscriber's numerical digits, or it may include office code digits as well. Since senders must be capable of operating with the standard kinds of signaling, four types are available for dial-pulse, revertive-pulse, multifrequency-pulse, and panel-call-indicator operation. Multifrequency pulsing is generally used for signaling between Number 5 offices, to and from Number 4 toll crossbar offices, to Number 1 crossbar, and to crossbar tandem offices.[4,5]

If the call is incoming from another office, the incoming trunk circuit associates itself with an incoming register through an incoming register link. The incoming registers receive information from senders, dials, or key sets in the distant offices and pass this information to the markers for establishing the switching connection either to a called subscriber line in the same office, or to a distant office when through switching of toll or tandem traffic is involved. Incoming registers, like senders, must be capable of operating with the standard kinds of signaling; hence there are dial-pulse, revertive-pulse, multifrequency-pulse, and *B*-switchboard registers.

The flexibility afforded by this switching plan can be illustrated by a simple manual switchboard analogy. Imagine a manual operator who has direct access to lines and trunks of every variety in the quantities needed. Over a preliminary connection she is quickly given complete information regarding the nature of each call. Then, knowing all she needs to about both calling and called parties, she dismisses the preliminary connection and establishes the talking path by assembling the proper combination of transmission, signaling, supervisory, and charging circuits required for that connection and connecting that combination between the jack of the calling line or trunk and the jack of the called line or trunk.

DESCRIPTION OF CIRCUIT OPERATION

The operation of the Number 5 Crossbar System will be described by tracing the progress of some typical calls through the system with the aid of the simplified block diagrams shown in Figures 2, 3, and 4. The connections will be dealt with in this order:

1. The calling subscriber is connected to an originating register for the purpose of registering the called number which is dialed. This is commonly referred to as a dial-tone type of connection.

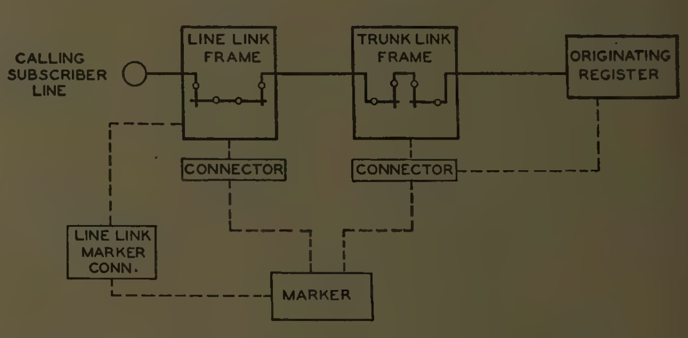


Figure 2. After the connecting path has been established, the marker, trunk-line connector, line-link connector, and line-link marker connector are released and the originating register transmits a dial tone to the calling subscriber

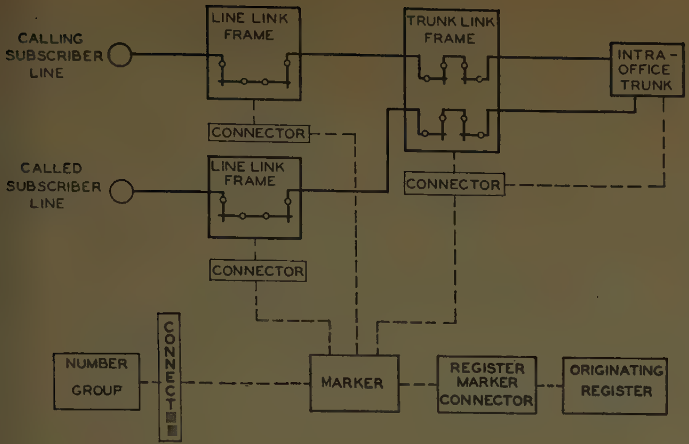


Figure 3. For an intraoffice call, talking connection is established from the calling subscriber through the intraoffice trunk to the called subscriber

2. The calling subscriber dials the number of a subscriber who is associated with the same office. This is known as an intraoffice call.

3. The calling subscriber dials the number of a subscriber who is associated with a distant office. This is known as an outgoing call.

There are, of course, many other kinds of switching connections which this office is capable of handling; however, these are basic and should give some understanding of the general circuit operation of the system.

Dial Tone Connection. (Figure 2.) A subscriber originates a call by removing the receiver from the switchhook which operates a relay associated with the subscriber's line. The operation of this relay causes the line-link frame, through the line-link marker connector, to seize one of the idle marker circuits and to inform this marker that a dialing connection is to be established.

The marker determines the identification and location of the calling line. If more than one subscriber line on this line-link frame is awaiting service, the marker singles one out for first attention.

At the same time as the marker is determining the identity of the calling line, it is also selecting an idle originating register circuit to serve this call. Several originating registers are associated with each trunk-link frame, and the marker determines which of the idle trunk-link frames has one or more idle originating registers, selects one, and connects to this trunk-link frame through its trunk-link connector. The marker then selects one of the idle originating registers associated with the selected trunk-link frame. Having determined the location of the calling line, the marker connects to the line-link frame, through the line-link connector, and transmits the calling-line location information to the selected originating register.

The marker will then choose an idle connecting path to extend the calling subscriber line through line-link and trunk-link frame switches to the selected originating register. To determine which connecting paths are already in use on other calls and are, therefore, unavailable for this dial-tone connection, the marker tests the line-link leads, the junctor leads, and the trunk-link leads of the possible paths. The marker selects the preferred connecting path which is available for use and operates the magnets on the crossbar switches to establish this path.

After the connecting path has been established, the marker, the trunk-link connector, the line-link connector, and the line-link marker connector are released, and the originating register transmits dial tone to the calling subscriber as an indication that dialing of the called subscriber may be initiated. As the subscriber dials the called subscriber directory number, it is recorded in the originating register for later use in completing either an intraoffice or an outgoing call.

Intraoffice Call. (Figure 3.) After the calling subscriber has dialed the complete called-subscriber directory number, the originating register, through the register marker connector, seizes an available marker. The originating register transmits to the marker the called directory number and the calling-subscriber line location. By examining the office code of the called subscriber number the marker determines that this call is for a subscriber associated with this office. As described in the following paragraphs, the marker then proceeds to establish a connecting path between the called subscriber line and an intraoffice trunk circuit which will be called a terminating connection, and a connecting path between the calling subscriber and the same intraoffice trunk circuit which will be called an originating connection.

To establish a terminating connection the marker, through the trunk-link connector, seizes an idle trunk-link frame which is associated with at least one idle intraoffice trunk circuit and selects one of these idle intraoffice trunks for service. At the same time as the marker is selecting an idle intraoffice trunk, it is also determining the line location of the called subscriber. To determine the line location of the called subscriber, the marker, through the number-group connector, seizes a number group and transmits to it numerics of the called-subscriber directory number. The number group translates the called-subscriber directory number into line-location information and transmits this and appropriate ringing information to the marker. After the marker has received the line-location information, the number-group connector and number-group circuit are released and the marker, through the line-link connector,

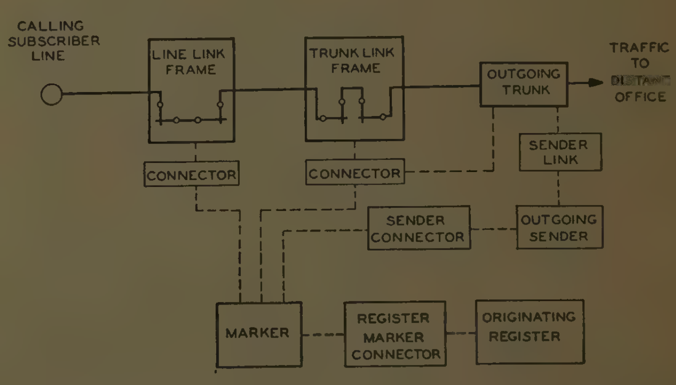


Figure 4. For an outgoing call the outgoing sender transmits the number through the sender link and the outgoing trunk to the distant office. The outgoing sender and sender link are then released and the call is under control of the outgoing trunk

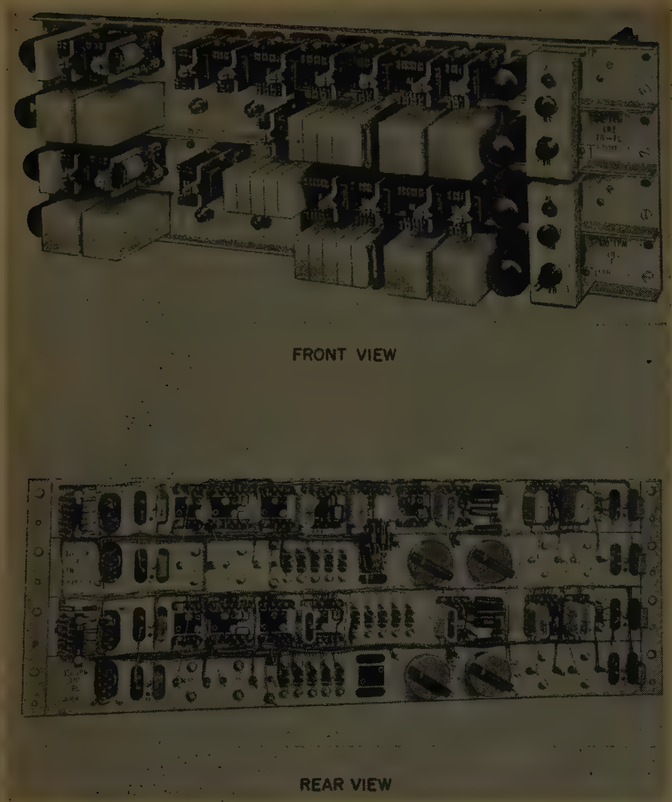


Figure 5. All Number 5 equipment is arranged in small subassemblies to facilitate assembling, wiring, and testing

seizes the line-link frame associated with the called subscriber line. The called line is tested to see if it is busy, and, if it is idle, the marker connects the called subscriber line to the selected intraoffice trunk through an available path.

After the marker has thus established the terminating connection, the line-link connector is released and the marker then proceeds to establish the originating connection. However, if the called line is busy, the calling subscriber is connected through a connecting path to a trunk circuit which transmits a busy tone to the calling subscriber.

To establish an originating connection either to the called line or to the busy-tone trunk circuit, the marker, through the line-link connector, seizes the line-link frame associated with the calling subscriber line and connects the calling subscriber line to the selected intraoffice or busy-tone trunk circuit, through an available connecting path.

After a talking path has been established from the called subscriber through the intraoffice trunk to the calling subscriber, the marker, the line-link connector, the trunk-link connector, the register connector, and the originating register are released and the switches are held under control of relays of the intraoffice trunk circuit.

Subscriber Outgoing Call. (Figure 4.) After the calling subscriber has dialed the complete called-subscriber directory number, the originating register, through the register-marker connector, seizes one of the idle marker circuits. The originating register transmits to the marker the called-subscriber directory number and the calling-subscriber line location. By examining the office code of the called number the marker determines that this call is for a subscriber associated with a distant office.

Assuming that this subscriber outgoing call is to a distant dial office, the marker, through an idle sender connector, seizes an idle outgoing sender circuit and transmits the called directory number to the selected outgoing sender. Having determined that an idle outgoing sender is available, the marker, through the trunk-link connector, seizes an idle trunk-link frame associated with at least one idle outgoing trunk circuit which connects to the required distant office and selects one of these idle outgoing trunks for service. After the marker has selected both the outgoing sender and the outgoing trunk circuit, the sender link circuit connects the selected outgoing sender to the selected outgoing trunk circuit.

When an idle outgoing trunk has been selected, the marker, through the line-link connector, seizes the line-link frame associated with the calling subscriber line and connects the calling line to the selected outgoing trunk through an available connecting path. After the connecting path has been established, the marker, the line-link connector, the trunk-link connector, the sender connector, the register connector, and the originating register are released.

The outgoing sender transmits, by the appropriate pulsing, the called directory number through the sender link and the outgoing trunk to the distant office to provide the information necessary for establishing a connection in the distant office to the called subscriber. The outgoing sender and the sender link are then released, and supervision of the call is under control of the outgoing trunk circuit.

EQUIPMENT DESIGN

The primary objective in equipment design for the Number 5 system was to exploit to the fullest extent the

Figure 6. The trouble recorder is a perforator which makes a card record of the information used by the maintenance force as an aid in locating trouble

flexibility inherent in the switching plan. The second objective was to standardize the arrangements in the fewest patterns with the fewest parts and assemblies for most economical production.

The equipment arrangements in the new Number 5 office are generally similar to those in other large crossbar offices. Lines of switch frames $11^1/_2$ feet high and about 40 feet long are arranged on one or more floors of the building. Dimensions for ceiling heights, column spacings, and maintenance aisles are those standardized for universal use in various types of offices some years ago.

All of the switching components are arranged on the various frames in ways which were calculated to provide the best association for production, service, and maintenance and at the same time facilitate additions for central office growth. Since it is desirable from a cost standpoint to have as much work as possible done in the factory, the equipment frames carry the largest possible groups of associated apparatus completely assembled, interconnected, and tested in the shop. Field installation is, in this way, reduced to setting up the frames on the office floor, interconnecting them with the interframe cables, and testing the components and the system as a whole before turning it over to the telephone company.

All Number 5 equipment is subdivided into small packages, each containing a basic combination of features. These packages, called functional units, are then used as the building blocks for all frame equipments. All functional units can be bench-assembled, wired, and tested and, where justified, straight-line assembly methods can be employed. Interconnecting wires, precut to length and preskinned, are run along the surface of the mounting plates which support the components and are connected as run. A new wire with plastic insulation was developed for this purpose which reduces wiring congestion, fire hazard, and contact troubles from lint. A typical functional unit is shown in Figure 5.

Frame equipment arrangements are similarly standardized to accommodate all needed groupings of functional units completely interconnected and tested in the factory. In order to make each frame as self-sufficient as possible, it is equipped not only with its particular complement of functional units, but with fuse panels and all other items which serve it. Every frame arrangement permits the frame and its common equipment and wiring to be manufactured apart from its functional units. Then, at a later stage in the assembly, units and frames can be brought together in as flexible a manner as required. Many combinations can in this way be assembled from a few standard frames and a relatively few functional units. Each office can be engineered and manufactured with just the features it needs and with as little custom-building as practicable.

MAINTENANCE FEATURES

In the development of the Number 5 system, it was a major design objective to produce a system which would be more nearly trouble-free than any system produced heretofore. In addition, if troubles could be made sufficiently infrequent, an office could be unattended for long periods of time with a resulting reduction in maintenance effort, testing facilities, and maintenance costs.

Figure 7. Facilities for maintenance, testing, and trouble recording are located in the maintenance center at Media, Pa. Here any of the major circuits of the Number 5 Crossbar System can be removed from service to minimize trouble reactions

Steps which have been taken toward the maintenance objectives include the following items:

1. In designing circuits there was an endeavor to employ relays and switches in arrangements which would enable these devices to perform their required functions with maximum ease and allow maximum tolerance of maladjustment. This provides margin to allow for changes in operating characteristics which are inevitable as a result of apparatus wear, aging, and other factors.
2. Contact locking and contact erosion has been minimized by extensive use of contact protection networks.
3. Many self-checking and trouble-detecting features are included in the common control circuits, particularly the marker. When a trouble is detected, a card record is made by the trouble recorder. Meanwhile, wherever possible, a second trial is made to establish the connection for the subscriber. Because of the extensive use of the marker for switching operations in this system, these features are more effective than in any earlier system.
4. A new device, known as an automatic monitor, has been provided and is arranged to check, automatically on a sampling basis, the pulsing features of the registers and senders while handling regular service. When troubles are found, the trouble recorder is engaged and a record made.
5. A new trouble recorder (Figure 6) was developed

for the Number 5 system. This is a type of perforator which is engaged by a common control circuit when trouble is encountered and makes a card record of essential information which can be used by the maintenance force as an aid in locating the trouble. It will automatically record a succession of trouble indications and is sufficiently fast in its operation to record a large volume of indications within a short period of time and to minimize delays to the circuits which encounter troubles. The Number 5 system also makes extensive use of the trouble recorder to indicate test results.

6. Portable test boxes and frame-mounted test circuits are made available for testing and maintaining circuits such as senders, registers, trunks, markers, and other circuit elements.

7. A simplified form of central office audible and visual alarms has been provided to direct attention to the presence of trouble conditions. The alarms are arranged to be transmitted to the maintenance force at another location when the office is unattended, and under these conditions an indication showing the nature or degree of the trouble is given.

Maintenance activity in crossbar offices is controlled from a maintenance center (Figure 7). This is the area in which all of the principal frames used in testing and trouble-recording operations are located. In Number 5 Crossbar this activity is controlled from the master test frame. This is actually a group of frames and includes the trouble recorder, the automatic monitor, register and sender test, trunk test, and the associated circuits, including the master test-frame connector which provides access to the various circuits for testing. Located here also are facilities which quickly permit taking any of the major circuits out of service to minimize trouble reactions. It is possible to obtain access to and test any of the individual major circuits in the office from the master test frame.

SUMMARY

The Number 5 System includes the following features:

1. The Number 5 system permits direct interconnection with all existing types of crossbar, panel, step-by-step, and manual offices. It can be used for a variety of sizes of offices with heavy or light traffic and can operate with few or many interconnecting offices of the various kinds. It can also operate with various types and combinations of numbering plans involving anywhere from 4 to 11 digits.

2. The Number 5 system has the ability to operate as a toll or tandem switching center for a moderate amount of toll or of tandem traffic. In this respect, it includes arrangements which can be used for nation-wide toll dialing.

3. The system is designed for long service life with a minimum of maintenance attention and prolonged periods of unattended operation. In the event of certain trouble conditions within the system, the second trial feature serves to maintain unimpaired service to the subscriber.

4. The Number 5 system exploits the common control principle to a greater extent than any previous system. The common controls are concentrated in a few markers.

5. The equipment arrangements utilize the flexibility inherent in the switching plan and in the circuit arrangements and at the same time provide standardization which tends toward efficient manufacture, job engineering, installation, and maintenance.

REFERENCES

1. Crossbar Dial Telephone Switching System, **F. J. Scudder, J. N. Reynolds.** *Electrical Engineering* (AIEE *Transactions*), May 1939, pages 179–92.

2. Fundamentals of the Automatic Telephone Message Accounting System, **J. Meszar.** AIEE *Transactions*, volume 69, 1950 (*Proceedings* T042).

3. Operator Toll Dialing, **J. J. Pilliod, H. L. Ryan.** *Bell Telephone Magazine* (New York, N.Y.), volume 24, 1945, summer section, pages 101–15.

4. Multifrequency Pulsing in Switching, **C. A. Dahlbom, A. W. Horton, Jr., D. L. Moody.** *Electrical Engineering*, volume 68, June 1949, pages 505–10.

5. Crossbar Toll Switching System, **L. G. Abraham, A. J. Busch, F. F. Shipley.** *Electrical Engineering* (AIEE *Transactions*), June 1944, pages 302–09.

"Baby" Atomic Rifle to Aid Chemists at Brookhaven

High-energy electrons and X rays will bombard water molecules as experiments with a "baby" Van de Graaff generator get under way in the Chemistry Department of Brookhaven National Laboratory at Upton, N. Y. The 2,000,000-volt electron rifle is available to universities and industrial laboratories wishing to study effects of radiation upon various substances.

Housed in a bullet-shaped steel pressure tank only five feet long and three feet in diameter, the generator is a descendant of the large atom smasher known as a Van de Graaff generator. High-energy electrons, or cathode rays, emerge from the tank in the form of a bluish beam. From a safe distance they can be seen as they strike a nearby target. X rays can also be generated.

Built by High Voltage Engineering Corporation of Cambridge, Mass., the device is the first and smallest of three Van de Graaffs to be operated for widely different purposes at Brookhaven. Use of the machine for bombardment of simple compounds by radioactive rays and particles, is expected to give new information on breakup, recombination, and distribution among different types of molecules. Experiments probably will be made on proteins and other complex living substances and stress tests run on materials of technological interest.

Possible applications of the atomic rifle include the study of effects of large doses of X rays on physical and electrical properties of insulators and various materials, particularly those used in construction and operation of nuclear reactors. Because the irradiation period is so small in comparison to duration of an entire experiment, the machine can serve a number of projects almost simultaneously.

Like other research facilities at Brookhaven, the new Van de Graaff is available to qualified scientists throughout the northeast.

Meter Operating Problems of a Public Utility

J. C. LANGDELL
FELLOW AIEE

TECHNICAL developments in metering equipment have been subjects of many interesting and valuable articles, but little has been recorded of the operating problems presented in the use of meters by public utilities and which require engineering consideration in their economic solution. The object of this article is to discuss briefly some of these problems with the thought that it may bring about greater engineering consideration for them. Major items of concern in meter operations are

1. Meter department personnel and training.
2. Selection of types of measurement to be utilized.
3. Meter installation.
4. Meter testing purposes.
5. Standardization of equipment and maintenance of accuracy.
6. Meter records.
7. Periodic meter testing.
8. Shop testing and maintenance of equipment.
9. Meter retirement.

A meter department capable of performing its functions efficiently and economically requires ample and suitably trained personnel including competent supervision and engineering talent. The provision and training of such personnel constitutes a difficult problem.

Co-operation of all operating departments concerned as well as commercial, accounting, and engineering departments are essential to the intelligent selection of the types of measurement to be utilized for the varying classes of service as determined by business and economic considerations. Unessential and uneconomic development of much equipment, later found inadequate for the intended purposes, frequently can be avoided through such consultation and competent advice, and improved and highly unified meter equipment can be made available for wide use. The operating characteristics of such equipment with respect to time can and should be suitably predetermined by well-co-ordinated acceptance-test procedures.

Because meters are installed generally in service wiring on customers' premises, these installations must be co-ordinated with the provisions of the National Electrical Code and applicable local ordinance and other legal requirements arbitrarily imposed. The meter department supervisory and advisory personnel will find it essential to be well versed in these matters and to follow all efforts to impose ill-considered legal requirements adversely affecting meter installation practices. Booklets covering details of the meter and service installation methods used will be found of value in fostering and maintaining standardized practices among contractors and electricians who make the installations, utility personnel dealing with the meters, and customers on whose property the meters are installed.

Meters and metering equipment are tested before installation to assure the accuracy of measurement when installed and periodically thereafter to assure continued accuracy with time. This is a major function of a meter department, but the efficacy of the entire testing program is dependent upon maintenance of the accuracy of the equipment used for the purpose. Thus, an operating utility must either provide for itself the laboratory equipment required to maintain accuracy standards or else must rely on other acceptable agencies. In either case, adequate equipment for the purpose must be made available. It need not be costly, and generally direct ownership can be justified in operations of reasonable size.

After metering equipment has been tested and installed, periodic maintenance requires some knowledge of its location in service. This presupposes a record, and experience has shown that an adequately designed record will not only make possible major economies in the testing procedure, but also will provide invaluable information as an aid in economical over-all operation of a meter department.

Many changes in the periodic testing and maintenance functions have been brought about in recent years by the installation of meters outdoors and the rapid increase in the number of meters in rural areas. House-to-house testing on customers' premises cannot be used effectively in widely scattered areas, and there is evidence that removal of all single-phase and self-contained polyphase meters for periodic test in the shop has advantages as a universal method in all areas. Mobile shops, which are moved to central locations with respect to meters to be tested in small areas, are also being used to a limited extent.

Increased volumes of shop testing, whatever the reason, coupled with increased operating costs make it essential to take advantage of all the recent developments in shop methods and equipment. It is readily practical to double the production of testing personnel through the use of recently developed testing equipment, actually with less physical effort than otherwise required.

Meter departments must be adequately housed and equipped and should be in well-chosen locations strategic with the territory served. Suitable equipment for all shop and outside functions are a necessity.

Finally, because meters, like any other items of utility plant, have a limited useful and economic life, a formal program for their routine retirement is a prime requisite to meter operations. Obsolescence of meters is dependent on many factors that must be suitably evaluated in determining such retirement programs.

Digest of paper 50-126, "Meter Operating Problems of a Public Utility," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Technical Program Committee for presentation at the AIEE Great Lakes District Meeting, Jackson, Mich., May 11–12, 1950. Not scheduled for publication in AIEE *Transactions*.

J. C. Langdell is with the Commonwealth Services, Inc., Jackson, Mich.

Filtered Output Ripple of Polyphase Rectifiers

C. K. HOOPER
ASSOCIATE AIEE

C. H. McADIE
ASSOCIATE AIEE

THE D-C OUTPUT obtained from rectifier power supplies is frequently filtered, particularly if the direct current is used with electronic communication equipment such as radio transmitters and similar apparatus. This filtering is necessary because the alternating component of voltage normally present in the output of rectifiers would result in objectionable hum or other disturbances in the equipment.

If the d-c power requirements are large, the rectifiers are usually of the polyphase type. Polyphase rectifiers present several advantages over single-phase types. One of these advantages is that smaller and less expensive filter components are required to reduce the load ripple amplitude to a given value than if a single-phase rectifier were to be used. The reason for this difference is that normally the amplitude of the a-c component of voltage is lower, and its frequency is higher for polyphase rectifiers than for single-phase rectifiers. Both of these conditions permit the use of smaller filter components.

In the case of a 3-phase double-way rectifier (a type commonly used with electronic equipment) the lowest ripple frequency component is six times the supply-line frequency and has an rms amplitude of 4.04 per cent of the no-load direct voltage.

The type of filter often used in this service consists of a series reactor followed by a shunting capacitor. This is sometimes called a choke-input filter. Usually only a single stage of filtering is provided.

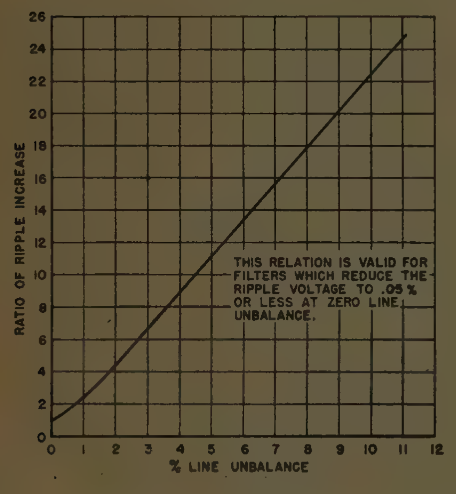


Figure 1. Ratio of ripple voltage increase in the filtered output of a 3-phase double-way rectifier as a function of line unbalance

If the 3-phase a-c supply does not have balanced voltages, then for the same type of rectifier an additional ripple component of lower frequency is present. This lower frequency component has a frequency of two times the supply-line frequency and an amplitude approximately proportional to the degree of line unbalance.

Under conditions of unbalanced supply line the effectiveness of the filter is reduced considerably because of this lower frequency component. It has been found that even a relatively small amount of line unbalance can result in a considerable increase in ripple amplitude in the filtered d-c output. For example, in the case of a 3-phase double-way rectifier having a filter of usual effectiveness, a line unbalance of only two per cent will increase the output ripple amplitude to over 400 per cent of the value which would be obtained if the a-c supply were balanced.

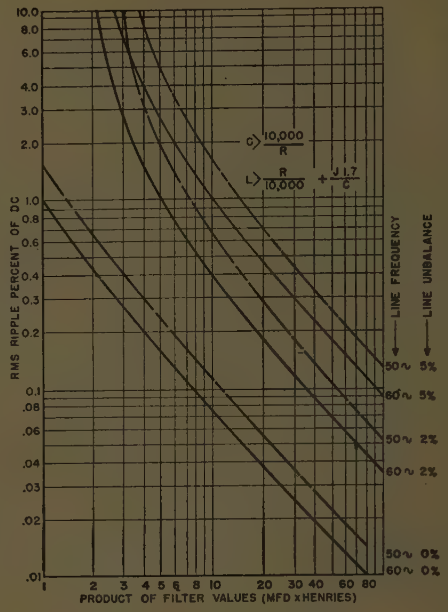


Figure 2. Output ripple from a single-stage low-pass choke-input filter used with a 3-phase double-way rectifier as a function of filter constants

If the filter is one which reduces the ripple amplitude to about 0.05 per cent or less (a common value for communication equipment), a simple equation can be used to express the relation between the amount of line unbalance and the ratio of ripple voltage increase.

This relationship is shown in curve form in Figure 1, from which can be seen the large effect line unbalance has on the output ripple. This curve applies to a 3-phase double-way or a 6-phase single-way rectifier using a single-section choke-input filter. It will be noted that the relationship expressed by this curve is independent of the supply-line frequency or the filter rating, provided the filter is effective to the value shown on this curve.

For less effective filters the curve shown in Figure 2 can be used which requires a knowledge of the filter constants and applies specifically to supply line frequencies of 50 and 60 cycles. Ripple values for 0-, 2-, and 5-per cent line unbalance are shown.

Digest of paper 50-125, "Effects of Supply-Line Unbalance on the Filtered Output Ripple of Polyphase Rectifiers," recommended by the AIEE Committee on Electronic Power Converters and approved by the AIEE Technical Program Committee for presentation at the AIEE North Eastern District Meeting, Providence, R. I., April 26–28, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

C. K. Hooper and C. H. McAdie are with the Westinghouse Electric Corporation, Baltimore, Md.

Analyzing Contactor Servomechanisms by Frequency-Response Methods

R. J. KOCHENBURGER
ASSOCIATE AIEE

An approximation method is proposed here for analyzing a servomechanism system in order to predict its performance or for designing a system according to desired specifications. This method is particularly adaptable in the selecting of compensating networks for improving the performance of contactor servomechanisms.

A METHOD is proposed here by which the frequency response of a nonlinear feedback control system may be employed for purposes of system synthesis and analysis. This extension of the frequency-response method, heretofore primarily associated with essentially linear systems,[1] is particularly convenient when a number of energy storage elements are involved and the classical or transient approach therefore becomes unduly cumbersome. The synthesis of given control system is also much more easily accomplished by methods based upon the frequency response.

The procedure is described in terms of its application to contactor servomechanisms because this particular type of nonlinear and discontinuous control system enjoys widespread usage. Figure 1 is a general block diagram of a typical elementary type of contactor servomechanism used to control angular position showing a functional division of the basic components. The distinguishing feature of these servomechanisms is the existence of a discontinuous power amplifier called a contactor means. Such a device may, for example, consist of electromagnetic relays, may involve electronic control circuits of the trigger or flip-flop type, or may employ abrupt cut-off types of hydraulic or pneumatic valves. Such a contactor means has the characteristic of producing abrupt changes in its output, called the correction signal, as its input, or control signal, is varied.

Earlier methods[2–5] proposed for studying such discontinuous control systems dealt directly with the transient response. In the treatment proposed here, a knowledge is obtained instead of the response of the system components to sinusoidal signals of various amplitudes and frequencies. From this knowledge, conclusions may be reached regarding the system performance which may permit the system to be analyzed or synthesized according to given specifications.

The first basic concept upon which this method is based is the division of the system components into two types: those which are linear and frequency-variant and those which are nonlinear and therefore amplitude-variant. The response of the frequency-variant components may be determined by the conventional methods employed in the treatment of the more familiar continuous systems.[1] A practical expression for the response of the amplitude-variant components requires an approximation which is now to be described.

The second basic concept is the approximation, just referred to, which permits the response of the amplitude-variant component, the contactor means, to be described by a contactor-describing function. The output of a contactor, in response to sinusoidal control signals, will be a periodic wave of rectangular shape. This output, or correction signal, may be described in terms of an average and fundamental harmonic component and of higher harmonic components. The remainder of the control system acts as a low-pass filter in most instances, and therefore these higher harmonic components are greatly attenuated in comparison with the fundamental component. It has been found that, in many control systems, these higher harmonics may be neglected and only the fundamental component of the correction-signal need be considered. Such an approximation permits the contactor-describing function to be expressed in relatively simple fashion as a function of control-signal amplitude and enables this function to be plotted in polar form as an amplitude locus.

It has been found convenient to plot the response ratio, or transfer function, of the linear and frequency-variant portion of the system in inverse form. This method of plotting frequently has been employed for synthesizing linear control systems.[1,6] The curve labeled "Locus of $g^{-1}(ju)$" in Figure 2 represents such a plot. The describing function of the contactor is then plotted as a second locus, in this case as an amplitude locus. The hairpin-shaped curve of Figure 2 represents this second locus. When these two loci are superposed as shown, their relative orientations indicate whether the control system will possess adequate dynamic stability and speed of response. In the case shown in Figure 2 the two loci intersect. This indicates that the system thus represented is capable of self-sustained oscillations of a specific frequency and amplitude. The frequency and amplitude can be determined directly from the loci diagram. For some applications, self-sustained oscilla-

Full text of an article based on paper 50-44, "A Frequency-Response Method for Analyzing and Synthesizing Contactor Servomechanisms," recommended by the AIEE Committee on Feedback-Control Systems and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1950. Scheduled for publication in *AIEE Transactions*, volume 69, 1950.

R. J. Kochenburger is Assistant Professor of Electrical Engineering, University of Connecticut, Storrs, Conn.

The material described in this article represents some of the results obtained as part of a doctoral thesis research program conducted by the author at the Massachusetts Institute of Technology. United States Air Forces, Air Material Command, Armament Laboratory, Wright Field, Ohio, sponsored the project under which this work was done. The aid of various members of the Electrical Engineering Department and Servomechanisms Laboratory staffs and of H. K. Weiss of the Aberdeen Proving Grounds is gratefully acknowledged. The suggestions and criticisms furnished by Dr. Gordon S. Brown, Director of the Servomechanisms Laboratory, in his capacity as thesis supervisor, were particularly helpful.

tions may be permissible, subject to limitations regarding amplitude and frequency. In other cases, such oscillations may be necessarily avoided and the two loci cannot be permitted to intersect. In this latter instance, the degree of stability is of interest, that is, the rate at which transient oscillations disappear after a disturbance. Conclusions regarding the degree of stability may also be reached by means of the loci diagram.

One of the most important applications of this procedure is its use in selecting suitable compensating networks when designing a control system. By means of this method, phase-lead type and proportional-plus-integral type compensating networks[1] have been selected to improve the performance of representative systems. Experimental tests indicated that the improvement predicted did occur in a physical system and that, as a matter of fact, even the most elementary forms of contactor control systems could be improved by the introduction of some simple compensating network.

The validity of the method described here was tested by comparing the results predicted by this procedure with those obtained by more exact, but more tedious, mathematical methods and by experimental tests on a control-system simulator. The simulator used for these tests consisted of a system conforming to the general arrangement shown in Figure 1. Its design was such that the various circuit constants could be varied and so that extraneous effects could be minimized. The percentage agreement was generally within ten per cent as regards predictions concerning speed of response and stability. This degree of accuracy corresponds to that frequently obtained when studying continuous systems, in view of the simplifying approximations necessary in such studies, and might be considered as adequate for most engineering purposes.

Figure 1 represents a simple form of contactor servomechanism. Some even more elementary forms exist where no compensating networks are used and the error signal directly actuates the contactor. In these cases, the control signal and error signal are identical. In other cases, the system may be more complicated than shown. For example, the feedback path may involve dynamic lags, instead of consisting of the direct path shown in Figure 1. The general method being described may be applied to such systems as well.

Figure 3 illustrates three frequently encountered forms of contactor characteristics. In Figure 3*A*, the output or correction signal D is dependent only upon the sense of the control signal C. In this case, the contactor will cause the servomotor to increase the output θ_o when the control signal is positive and to decrease the output when the control signal is negative. These two respective states are represented by the correction signal being mathematicall expressed by $D=+1$ and $D=-1$.

Figure 3*B* shows a contactor characteristic involving an inactive zone. This zone corresponds to a range of control signal C of magnitude Δ. When the control signal is within this range, the contactor calls for no correction and its output is mathematically represented by $D=0$. Such an inactive zone may be considered as an inverse measure of system gain. It represents the range of error which the system might have under static conditions without any corrective action taking place. Some inactive zone is unavoidable with many physical forms of contactors. Furthermore, some inactive zone of a magnitude small enough to satisfy the static-error specifications is generally desirable because of the contribution of this zone to dynamic stability.

Figure 3*C* shows a contactor characteristic involving a hysteresis effect as well as an inactive zone. Such an effect corresponds to a property of most contactors, such as electromagnetic relays, to require different values of control signal for initiation and cessation of corrective action. The control signal differential corresponding to this effect is designated as h and called the hysteresis range. Figure 3 shows the nonreversible nature of the characteristic when a hysteresis effect exists. It can be shown that such hysteresis frequently adversely affects the dynamic stability of the system, and therefore the hysteresis range should be made as small as design limitations will permit.

The performance criteria of contactor servomechanisms are basically the same as for continuous types. Static accuracy is determined by the inactive zone range rather than by gain, and specifications regarding it may be met by keeping this range within specified limits.

Dynamic accuracy specifications, defining the extent to which errors are minimized when the system is responding to a disturbance, are best met by:

1. Using a runaway velocity that is as large as the stability limitations and servomotor capabilities permit.

2. Having the frequencies associated with any damped transien oscillation as high as possible.

3. Having an adequate degree of stability for transient oscillation of amplitude greater than the region of error tolerance.

A distinction must be made between the stability requirements imposed on nonlinear systems and those imposed on linear types. For the former, continuous self-sustained oscillations of a small amplitude may be permissible under some circumstances. For the latter, the amplitude of any self-sustained oscillations would tend to increase to an undesirably high value.

For contactor servomechanisms, performance requirements may be met by specifying a range of inactive zone con

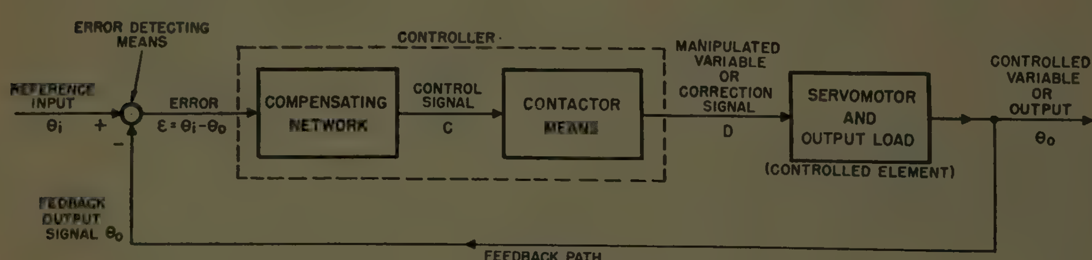


Figure 1. Block diagrar of a simple contacto servomechanism

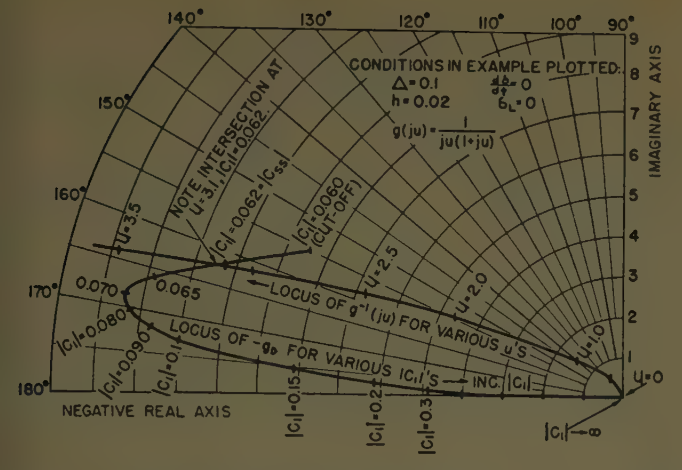


Figure 2. Construction of frequency and amplitude loci diagram to determine stability

sistent with the static accuracy requirements and a runaway velocity consistent with the desired speed of response. Once these are chosen, the major problem remaining is the selection of components which will provide adequate stability. The remainder of this article is devoted primarily to the problem of stability.

The assumption commonly employed in the study of continuous feedback control systems, that all components possess linear characteristics, will be applied to all components of a contactor servomechanism except the contactor. Each of these components may then be described in terms of its transfer function or ratio of output to input signal.

The transfer function of the servomotor may be expressed as a complex function of angular frequency, u, as:

$$G_s(ju)=\frac{\theta_0(ju)}{D(ju)}=\frac{R(1+ju\tau_1)(1+ju\tau_2)\ldots}{ju(1+juT_1)(1+juT_2)\ldots} \qquad (1)$$

The τ's and T's of this relation are time constants and may be real or complex. The above form of transfer function applies to the most common form of servomotor which would approach a condition of constant output velocity of R output units per second if a constant correction signal $D=+1$ were maintained. The quantity R is therefore called the runaway velocity. As was previously mentioned, a high runaway velocity improves the speed of response but makes the problem of obtaining adequate dynamic stability more difficult. The transfer function of the servomotor may be computed from design constants or determined by experimental measurements. Transfer functions of all other essentially linear components of the system may be similarly determined and expressed.

The next step in the procedure is the determining of the combined transfer function, including all of the linear frequency-variant components of the system. This combined transfer function is simply expressed as $G(ju)$ and is mathematically equal to the product of the component transfer functions. From a physical standpoint it may be described as the ratio of the control signal produced by the controller to the correction signal applied to the servomotor when the control loop is opened by eliminating the contactor and when zero input signal, θ_1, is applied to the system. A nondimensional inverse form of this over-all transfer function, or $g^{-1}(ju)\sim 1/G(ju)$, is determined and plotted as a polar locus over the complete range of frequencies u. This has been done in obtaining the frequency-variant locus labeled "Locus of $g^{-1}(ju)$" in Figure 2.

In order to apply the frequency-response method, it is necessary to relate the output-input characteristic of the contactor in terms of a describing function. The nonlinear characteristic of the contactor makes such a function difficult to express mathematically unless the previously mentioned assumption is made. The principle of linear superposition, upon which the conventional analysis methods depend, does not apply in the case of a contactor servomechanism. The assumption referred to involves an approximate method by which the contactor may be described in terms of only the average and fundamental harmonic components of the correction signal. In order to determine whether such a procedure is justified, let it be assumed that a sinusoidal control signal of the form

$$C=C_0+C_1\cos u\phi \qquad (2)$$

is applied to a typical contactor. Suppose this contactor has the general characteristic shown in Figure 3C. The resulting correction signal will have a rectangular wave shape as shown in Figure 4*A*. The instant of time at which a control signal of increasing magnitude attains a value corresponding to one of the outer inactive zone boundaries, that is, when $C=\Delta/2+h/2$ or $C=-(\Delta/2+h/2)$, will mark the beginning of a positive or negative corrective pulse, respectively. As shown in Figure 4*A*, these pulses are initiated at instants of time represented in angular measure (based upon the fundamental angular frequency) by the angles $(\alpha_1-\beta_1)$ and $(\pi+\alpha_2-\beta_2)$, respectively. Similarly, instants when a control signal of decreasing magnitude attains a value corresponding to the inner inactive zone boundaries, that is when $C=\Delta/2-h/2$ or $C=-(\Delta/2-h/2)$, will mark the end of a corrective pulse. The instants corresponding to these extinction points are designated in Figure 4*A* by the angles $(\alpha_1+\beta_1)$ and $(\pi+\alpha_2+\beta_2)$, respectively. In summary, the angles $2\beta_1$ and $2\beta_2$ represent the duration of positive and negative pulses, respectively, and the angles α_1 and α_2 represent the phase lags associated with the respective pulses. The phase lags are caused by the contactor's hysteresis.

The solid line of Figure 4*A* shows the correction signal D.

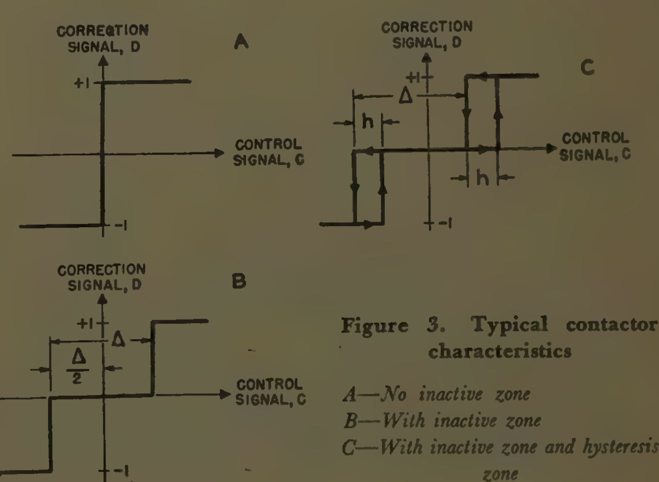


Figure 3. Typical contactor characteristics

A—No inactive zone
B—With inactive zone
C—With inactive zone and hysteresis zone

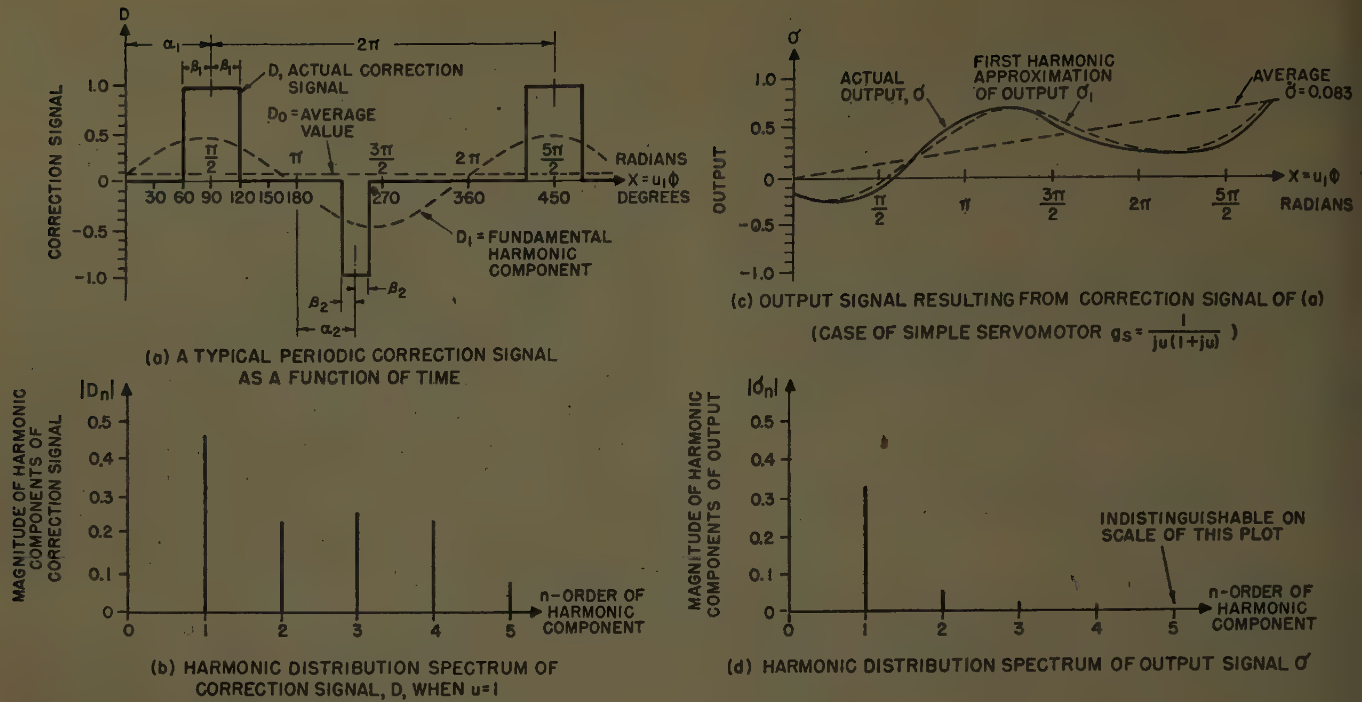


Figure 4. Comparison of the exact response of a servomotor with that obtained by the fundamental harmonic approximation

The horizontal broken line is a plot of the average component D_o. The broken sine curve is a plot of the fundamental harmonic component D_1. The higher harmonic components of D, which contribute to the sharp corners of the rectangular shape, are not shown.

If the correction signal consisted only of D_o and D_1, only sinusoidally varying signals would exist throughout the system when sinusoidal inputs were applied. The contactor would then appear as a quasi-linear transfer device in that it could be considered as a linear amplifier for any given constant amplitude of control signal. It would not operate as a truly linear device because of the nonlinear relationship between input and output amplitudes. Considering the contactor as such a quasi-linear device will permit the frequency-response method to be used in determining the system stability for any given control-signal amplitude. The approximation which permits the higher-harmonic components to be neglected so that the quasi-linear representation of the contactor may be employed must now be justified.

Figure 4 shows the relative importance of the harmonic components of the signals in a typical contactor servomechanism. Figure 4*A* shows a typical rectangular correction signal resulting from a periodic control signal. Figure 4*B* represents the harmonic spectrum associated with this correction signal. It is assumed, for example, that the servomotor has the transfer function $G_s(ju) = R/ju(1+ju)$, and that the fundamental nondimensional frequency of the control signal is designated by the relation $u=1$. Under these considerations, an exact determination of the resultant servomotor output θ_o obtained by a mathematical determination of the repeated transients, would appear as plotted by the solid-line curve of Figure 4*C*. (In Figure 4, the symbol σ is the nondimensional equivalent of the output θ_o.) The harmonic distribution of this output signal is shown plotted in Figure 4*D*. It may be seen that, while the original correction signal D possessed higher harmonic components of significant amplitudes (referring back to Figure 4*B*), these higher harmonic components have relatively small amplitudes, compared with the fundamental, when measured as part of the output signal.

The minor importance of the role played by the higher harmonic components is also demonstrated by the broken-line curve of the output response in Figure 4*C*. This curve represents the output response which would have been obtained if only the average and fundamental components of the correction signal had been present. It may be seen that this latter response is a fairly good approximation of the exact response.

If the higher harmonic components may be considered negligible as far as the output signal is concerned, their contribution to the error and control signals will generally have minor significance. This in turn tends to justify the original assumption of a truly sinusoidal control signal.

It is therefore proposed that the frequency-response method of analysis be used where the contactor characteristic is described in terms of a quasi-linear describing function g_{D_1}, the subscript 1 being used to indicate that the describing function takes into account only the fundamental harmonic component. This function neglects the higher harmonics with the following justification:

1. The normal frequency spectrum of a rectangular wave involves progressively smaller amplitudes for increasing orders of the harmonic components.

2. Most servomotors serve as effective low-pass filters and minimize the importance of the higher harmonic components.

It is conceivable that when servomotors exhibit marked resonance effects, the validity of the approximation may suffer under certain conditions where one of the neglected har-

monic components might have a frequency near resonance and its effect on performance might, therefore, be particularly prominent. This approximation is proposed so that the frequency-response method can be employed.

The contactor may be represented approximately in the manner just described and cases involving the application of constant rates of input change or constant load disturbances can be taken into account. However, this entails additional mathematical complication because the duration of positive and negative corrective pulses will differ ($\beta_1 \neq \beta_2$). For brevity, only the case where symmetrical corrective operation occurs ($\beta_1 = \beta_2$) will be discussed. This implies the condition of zero average load torque and zero average rate-of-change of input. The ratio of the fundamental harmonic component of the correction signal D_1 to the control signal C_1 is expressed as a complex quantity called the contactor describing function g_{D_1}. Such a function involves an amplitude ratio $|g_{D_1}|$ and, when hysteresis effects exist, a phase-lag angle $\underline{/g_{D_1}}$ as well.

Figure 5 shows the amplitude and phase angle of a typical contactor describing function plotted versus control-signal amplitude. A family of curves is shown, each curve representing a given ratio of hysteresis range to inactive-zone range. From such data, a polar-amplitude locus of the describing function $\boldsymbol{g}_{D_1}$ may be plotted and superposed on the locus of the frequency-variant transfer function. This was done in constructing Figure 2.

When applying the frequency-response method of treatment, the absolute stability of a system may be determined by expressing the response ratio, or ratio of output to input, in analytic form. For a servomechanism of the type shown in Figure 1, this ratio would be

$$\frac{\sigma(ju)}{\delta(ju)} = \frac{g(ju)g_{D_1}}{1+g(ju)g_{D_1}} = \frac{g_{D_1}}{g^{-1}(ju)+g_{D_1}} \tag{3}$$

In the foregoing expression the contactor-describing function is constant and independent of frequency for any given control-signal amplitude. For such a system to be stable for any amplitude, the denominator of the expression can have no roots of (ju) with positive real parts. The graphical test for this condition is already well known.[4] The locus of the sum $[g^{-1}(ju)+g_{D_1}]$ is plotted in polar form as a locus of the frequency as in Figure 6. In this diagram the vector $\boldsymbol{g}_{D_1}$ corresponds to the describing function g_{D_1} for any given control-signal amplitude. If, as the frequency locus is traversed in the direction of increasing frequencies over the range of frequencies, the polar origin always appears to the left, the response will be stable. The system represented by Figure 6*A* is therefore stable and that represented by Figure 6*B*, unstable.

Figure 7 is a corresponding diagram in which the coordinate axes have been linearly translated as shown. Such a translation permits the locus of $g^{-1}(ju)$ to be drawn independent of the vector $\boldsymbol{g}_{D_1}$. The point Q, formerly the origin, is now the tip of the negative vector $-\boldsymbol{g}_{D_1}$. Point Q is now the critical point which must appear to the left as the frequency locus is traversed.

The stability criteria given applies only for a specific

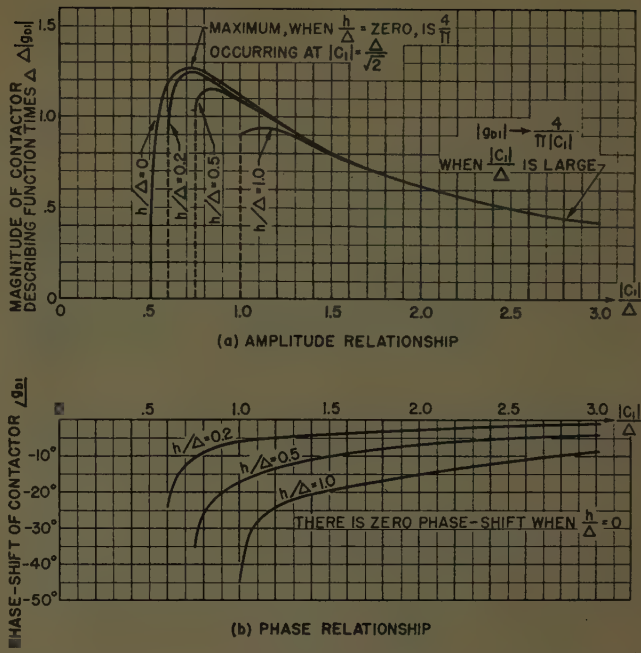


Figure 5. Plot of the contactor-describing function for characteristics shown in Figure 3C for the case of zero load torque and zero input velocity

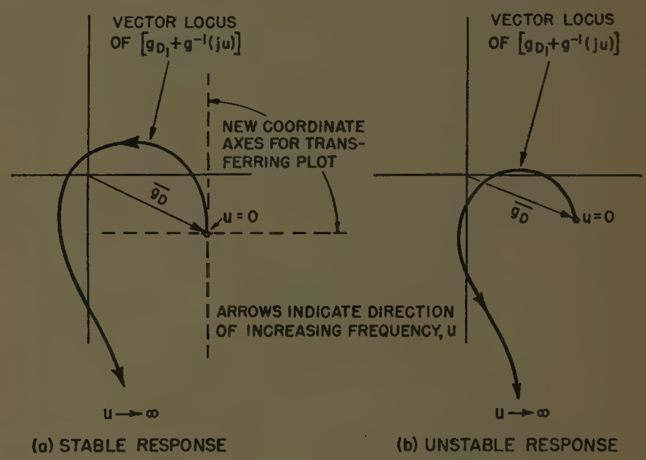


Figure 6. Inverse response-function loci for single-loop servomechanism showing the requirements for stable and unstable response

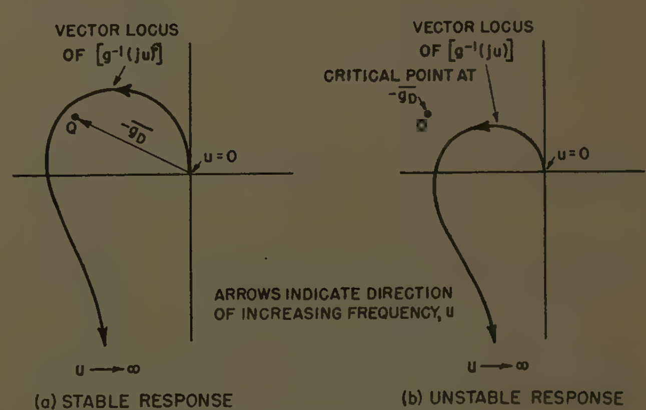


Figure 7. Inverse transfer-function loci for single-loop servomechanism. Location of point Q determines the stability of the system

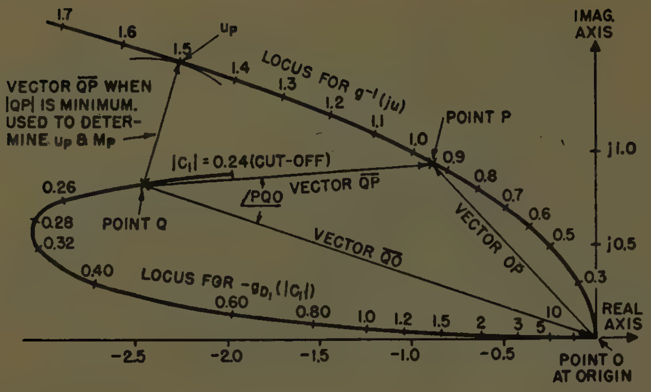


Figure 8. **Vector relationships in the loci diagram; these magnitudes are used in determining the stability of the servomechanism system**

control-signal amplitude where the describing function is a constant represented by a fixed vector terminating at the critical point Q. In order to investigate stability for all amplitudes, it is necessary to draw the locus of all points Q over the complete amplitude range. Such a locus is the amplitude locus referred to previously. An example of such a locus was given in Figure 2. In Figure 2 it may be noted that for values of control-signal amplitude C_1 greater than 0.062, the point Q lies in the stable region. Any oscillations that may exist because of past disturbances will tend to diminish in amplitude. Values of amplitude between the contactor cut-off point $C_1=0.060$ and $C_1=0.062$ result in locations of Q in the unstable region. Oscillations occurring in this range will tend to expand in amplitude. It may be seen that, in either case, there will be a tendency for the oscillations to vary in amplitude so that the operating point on the amplitude locus will move toward the point at which the two loci intersect. Such an intersection is called a point of convergent equilibrium and corresponds to a condition of self-sustained oscillations at a specific frequency and amplitude.

In a practical application it is not only necessary to know whether or not a system is stable; the question also arises—how stable? Experience with continuous control systems shows that a low degree of stability, that is, poor response damping following transient disturbances, are manifested by peaks in the amplitude-response curve of the system when the amplitude-response ratio is plotted against frequency. The magnitude of the ratio expressed in equation 3 is this ratio. The magnitude may be determined graphically from the loci diagram as shown in Figure 8. In this diagram the vector $\boldsymbol{QO}$ represents the numerator (g_{D_1}) of equation 3 for a specified control-signal amplitude. The vector $\boldsymbol{QP}$ represents the denominator $(g^{-1}(ju)+g_{D_1})$ of this relation for any specified frequency. The amplitude ratio is therefore simply the ratio of the length of the $\boldsymbol{QO}$ vector to the length of the $\boldsymbol{QP}$ vector. If this ratio is determined over the ranges of amplitude and frequency of interest, any undesirable peaks or excessive values of this ratio may be detected. By correlating this test with experimental investigations, it was found that if a system is designed so this ratio never exceeds a factor of two, the degree of stability is generally adequate.

In conclusion, a frequency-response method of analysis and synthesis may be adapted to contactor servomechanisms by employing a simple approximation. This method is usually capable of providing sufficiently accurate results for engineering applications.

The performance of contactor servomechanisms can be materially improved, in even the simplest cases, by the introduction of suitable compensating networks. The proposed frequency-response method of treatment is particularly adaptable to the selection of such networks.

The approximate method of treatment used here is also generally applicable to the analysis and synthesis of many other nonlinear systems. It might prove of particular value if the nonlinear effects such as backlash, coulomb friction, saturation, and so forth, appearing in essentially linear servomechanisms, were treated by this means.

REFERENCES

1. Principles of Servomechanisms (book), **G. S. Brown, D. P. Campbell.** John Wiley and Sons, Inc., New York, N. Y. 1948.

2. Theory of Servomechanisms, **H. L. Hazen.** *Journal,* Franklin Institute (Philadelphia, Pa.), volume 218, number 3, September 1934, pages 279–330.

3. Analysis of Relay Servomechanisms, **H. K. Weiss.** *Journal of the Aeronautical Sciences* (New York, N. Y.), volume 13, number 7, July 1946.

4. Fundamental Theory of Servomechanisms (book), **L. A. MacColl.** D. Van Nostrand, New York, N. Y., 1945. Appendix, "Study of a Simple On-Off Servomechanism."

5. An Analysis of Relay Servomechanisms, **D. A. Kahn.** AIEE *Transactions,* volume 68, part 2, 1949, pages 1079–88.

6. Parallel Circuits in Servomechanisms, **H. T. Marcy.** AIEE *Transactions,* volume 65, 1946, pages 521–9.

New Radio Memory Tube

Development of a radio tube that can remember what it is told and reproduce its information on request was announced recently by scientists from the Massachusetts Institute of Technology. The new 400-digit electrostatic storage tubes operate by storing "dots" of electric energy on a round storage surface. Each tube will record a choice of only two digits—either zero or one, "yes" or "no"—in any of 400 different positions. The development is thus especially tailored to the needs of that type of computing machine which solves all its problems in terms of so-called binary digits. In such machines a numerical system involving only two digits is substituted for the familiar 10-digit system. The storage tube is built somewhat like a television tube. A fast, high-voltage electron beam is used as the "writing beam" to apply "yes" or "no" voltages to a storage surface. A smaller stream of low-speed electrons continuously sprays this same target surface to hold the information from leaking off. The storage tube's "memory" takes place on electrical islands made by beryllium metal deposited on a sheet of insulation in a minute checkerboard pattern. The "writing" beam of the tube can select a small area of this storage surface consisting of 10 to 20 adjacent beryllium islands, and apply either of two voltages, one meaning "yes" and one meaning "no." Then later the beam can be redirected at the area on which needed information is stored in order to read off the signal it applied earlier.

Automatic Control of Ignitron Rectifier Stations

E. J. CHAM
ASSOCIATE AIEE

W. A. DERR
MEMBER AIEE

THE BASIC elements of an ignitron rectifier installation consist of a rectifier, a rectifier transformer, and the necessary switchgear equipment. The rectifier and the rectifier transformer are the same whether the station is automatically or manually controlled.

The switchgear includes the d-c circuit breakers, the a-c circuit breaker, and the protective and control relays. In the application of the switchgear equipment, consideration must be given to the fact that rectifiers are subject to arc-backs. The occurrence of arc-backs in rectifiers is random in nature. Up to the present time it has not been found possible to eliminate arc-backs absolutely. Therefore, the switching means provided for a rectifier must be arranged to prevent damage to any of the components of the installation and to minimize service interruptions due to arc-backs.

The control relays are applied to fit the operating methods adopted for the station. They govern the starting and stopping sequences employed. Protective devices provide for shutdown of the ignitron rectifier for conditions which could result in damage to equipment if maintained. The protective devices are usually arranged either to lock the unit out of service until manual reset of a lockout relay or to stop the unit with automatic restarting allowed when the trouble no longer exists.

These trouble conditions cause shutdown and lockout: a-c overcurrent for a definite time interval; an open ignitor; high rectifier temperature; unsuccessful automatic reclosing; low pressure of cooling water; and high mercury-vapor vacuum-pump temperature (pumped type only). For some trouble conditions, shutdown occurs with automatic restarting. They are the following: single-phase, reverse-phase, or low auxiliary voltage; thermal overload; transformer overtemperature; and a loss of vacuum in the pumped-type rectifier.

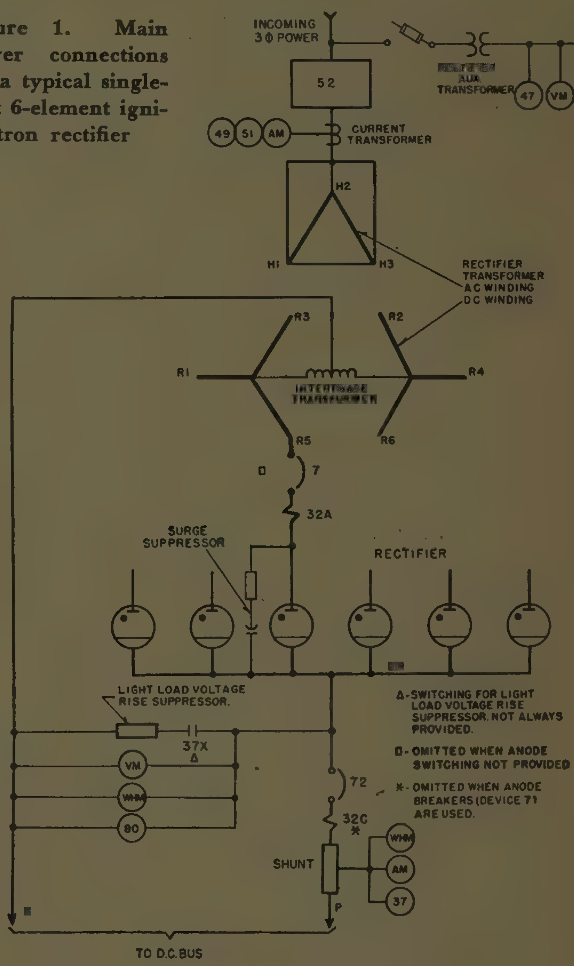
Figure 1 shows the main power connections for a typical single-unit 6-element ignitron rectifier. This diagram applies to either the pumped-type or sealed-type ignitron rectifier.

When neither the positive nor negative output of the rectifier is grounded the rectifier is insulated from ground. For such ungrounded service it is usually desirable to ground the rectifier excitation cabinet solidly, as well as all of the switchgear panels and structures.

If the negative of the rectifier is grounded, it is necessary to insulate the rectifier unit from ground. For such grounded service and rectifier voltages up to 300 volts it is customary to ground the rectifier excitation cubicle as well as all of the switchgear panels and structures. However, for rectifier voltages above 300 volts it is customary to insulate the rectifier excitation cubicle as well as all of the switchgear panels and structures with a single connection to ground through a high-resistance ground-detecting relay circuit.

The voltage drop of an ignitron rectifier remains essentially fixed from light load to rated load. The major

Figure 1. Main power connections for a typical single-unit 6-element ignitron rectifier



voltage drop is due to the resistance and reactance of the transformer. Both the reactance and resistance drops are directly proportional to the load currents. Therefore, the regulation curve of an ignitron rectifier is virtually a straight line. This simplifies paralleling of several rectifiers as well as paralleling with other conversion equipment in the system.

Economic considerations often result in the use of supervisory control equipment to provide the necessary controls and indications for an automatic rectifier station. Ignitron rectifiers are well suited for automatic operation since the starting and stopping sequences are quite simple.

Digest of paper 50-131, "Automatic Control of Ignitron Rectifier Stations," recommended by the AIEE Committee on Substations and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer and Pacific General Meeting, Pasadena, Calif., June 12–16, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

E. J. Cham and **W. A. Derr** are with the Westinghouse Electric Corporation, East Pittsburgh, Pa.

Lightweight Turbine Generator Rotors

T. DE KONING

A NEW rotor design has been developed which lifts the present limitations, imposed by the heating and the centrifugal force, upon non-salient-pole rotors and turbine generators. The higher the speed of a device, the lighter it must be to fulfill its functions properly, so the need for high strength and light weight is taken into account.

Aluminum alloys and magnesium alloys have high strength in relation to weight as well as good heat and electrical conductivity, weldability, damping capacity, and protective surfaces.

Compare a rotor section of present design (Figure 1*A*) with a rotor section as proposed (Figure 1*B*). The weak tooth root, which holds the centrifugally heavy trapezoidal tooth, the field coil, and the wedge is replaced by a tooth shape ideal from a mechanical and magnetic point of view.

Extrusion is a favored process for magnesium. The conductors have enough inherent strength to relieve the rotor tooth tips of their load and that of the wedges. Magnesium conductors need three times the cross section of copper conductors, everything else being equal. With a terminal voltage of 80 volts instead of the customary 250 volts, the number of turns per slot is reduced to one-third.

In the present rotors about 40 per cent of the slot space can be used for conductive material, 40 per cent is needed for the insulation, and 20 per cent for the wedge and bottom cooling spaces. With lightweight rotors the slot space is about 20 per cent larger. About 85 per cent of the space can be used for conductive material. The mean-turn length of the coils is 4 to 10 per cent shorter, the full-load resistance due to lower temperature 8 per cent less.

For a 2-pole 60-cycle 50,000-kva turbine generator the temperature drop in the rotor insulation is about 24 degrees centigrade, in the rotor teeth a further 24 degrees centigrade, or a total of 48 degrees centigrade. Assume that with lightweight rotors one-fourth of the periphery is taken up by the middle conductors, which remove two-thirds of the heat losses leaving one-third to the teeth. The equivalent total temperature drop is now 8 degrees centigrade.

Figure 2 shows a wiring sketch of a lightweight rotor.

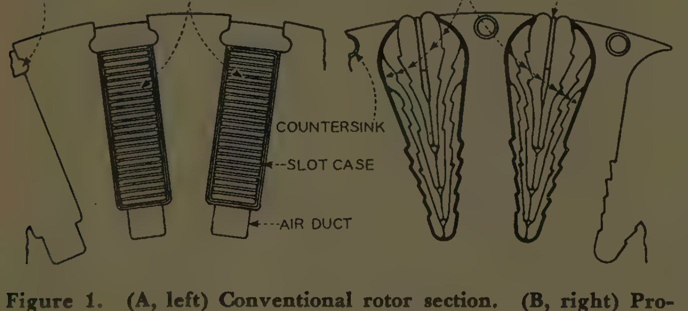


Figure 1. (A, left) Conventional rotor section. (B, right) Proposed rotor section

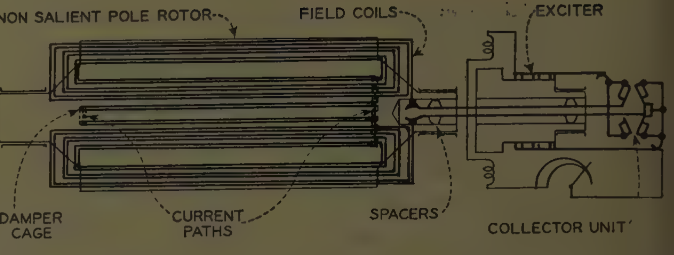


Figure 2. Main circuits of lightweight rotors. Conductor ends are welded together to form field coils

The conductor ends are welded together to form the field coils. Magnesium containing $1^1/_2$ per cent manganese is well known for its excellent weldability. The strength of the weld, as is, is about two-thirds of that of the extruded shapes. The wedges provide useful high-pressure contacts.

The pressure exerted on each side of a wedge is equal and can easily be 40 times the pulling pressure. Differences in the width of slots and shapes has no influence upon the pressure exerted. The pressure can be varied over the rotor length. The weight of the wedge is small so the centrifugal force is of no influence. Local projections can be used where a conductor must form an electric contact with the slot wall or another conductor.

The conductors covered with a laquer-reinforced oxide coating are laid in the slots from the rotor periphery, one at a time, the outer ones first. These are spread apart until they lock with the corresponding slot walls, which are covered with a thin sheet of insulation. After this the next conductors are laid in and spread apart. This goes on until the last inner conductor is laid in.

The following advantages may be expected with this scheme:

1. About three-fourths of the weight, one-half of the inertia, and twice the maximum peripheral speed of the equivalent present type of rotors.
2. About one-sixth of the maximum temperature drop, seven-eighths the field coil wattage, shorter mean-turn length, lower temperature; assuming that the same ampere-turns are needed.
3. The well-developed tooth tips and the improved tooth form decrease the magnetic leakage, as well as the ampere-turns and the winding space needed.
4. The segmental wedges lock the rotor solidly together, squeeze out the air layers, eliminate bending forces on the rotor tooth feet, and can smooth the flux distribution on the poles.
5. The damper cage and the field windings can be simplified by the use of elastic high-pressure spot contacts.

Digest of paper **50-27**, "Lightweight Turbine Generator Rotors," recommended by the AIEE Committee on Rotating Machinery and approved by the AIEE Technical Program Committee for presentation at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1950. Not scheduled for publication in AIEE *Transactions*.

T. de Koning is a Consulting Engineer, Philadelphia, Pa.

Fundamental Processes in Gaseous Tube Rectifiers

A. W. HULL

The theory involved in the phenomena occurring in gas-filled rectifier tubes is discussed here. It is shown how the two basic laws of electronics, the Richardson-Laue-Dushman equation of thermionic emission and the Child-Langmuir space-charge law, affect the behavior of these tubes.

MANY MODERN industries owe their existence to electronic tubes. For example, in long-distance telephony, talking movies, radio, television, and radar, the electronic components are essential elements for which there are no alternatives. These components are principally triodes, pentodes, magnetrons, and cathode-ray tubes.

Other applications use vacuum tubes because they do the job better or more economically than alternative devices. Rectifiers are in this category. In most of their applications, electronic rectifiers have nonelectronic competitors. Thus electronic gaseous diodes must compete with copper oxide and selenium rectifiers for low-power uses, and with rotary converters, motor-generators, and synchronous-contact rectifiers in high-power applications, while in the very special field of converters for high frequency the vacuum diode has a strong competitor in the recently developed germanium rectifier.

The gaseous rectifiers to be considered are high-pressure diodes, of which the argon-filled Tungar is an example; and low-pressure phanotrons, thyratrons, mercury-arc rectifiers, and ignitrons. However, emphasis will be centered on the fundamental processes in these devices rather than on the devices themselves or their applications.

It is convenient to begin the discussion of fundamental processes with the vacuum diode since it embodies, in simplest form, two of the most important processes of gaseous rectifiers, namely, electron emission and space charge. Qualitatively, the vacuum diode is a hot cathode surrounded by a closely spaced cold anode in a good vacuum. Quantitatively, its behavior is described completely by the two basic laws of electronics, namely the Richardson-Laue-Dushman equation of thermionic emission,[1] and the Child-Langmuir space-charge law.[2]

Electron Emission. The Dushman equation for electron emission is

$$i = AT^2 e^{-\frac{b}{T}} \text{ amperes per square centimeter} \quad (1)$$

where T is the absolute temperature and A and b are constants for each material. Only three materials are used to any extent as electron emitters in thermionic tubes, namely, tungsten; thoriated tungsten, containing about one per cent of thorium oxide; and oxide-coated nickel, the usual coating being 60 BaO + 40 SrO by weight. Table I gives typical data for emitters of these three materials.

Space Charge. Langmuir's space-charge equations for parallel-plane electrodes d centimeters apart, are:
for electrons,

$$i = 2.33 \times 10^{-6} V_{ca}^{3/2}/d^2 \text{ amperes per square centimeter} \quad (2)$$

for ions of molecular weight M,

$$i = 5.46 \times 10^{-8} M^{-1/2} V_{ca}^{3/2}/d^2 \quad (3)$$

for electrons between concentric cylinders of radii r_0 and r,

$$i = 14.66 \times 10^{-6} V_{ca}^{3/2}/\beta^2 r \text{ amperes per centimeter length} \quad (4)$$

V_{ca} is the voltage between cathode and anode, r the radius of the anode (usually the outer cylinder), and $\beta^2 = a$ constant, a function of r_0/r, which may be taken as one when the cathode radius is small compared to that of the anode.

Function of Gas. The function of gas in rectifiers is to furnish ions to neutralize electron space charge. Space charge limits the practical current in vacuum diodes. This becomes evident if one considers a simple example in which the cathode and anode are large enough to approximate parallel planes (equation 2). If the planes are one centimeter apart, it may be seen at a glance from equation 2 that a current of one ampere per square centimeter would require a voltage drop in the tube of nearly 10,000 volts. For comparison, the caesium-vapor rectifier that will be described carries 20 amperes per square centimeter with a voltage drop of 3.5 volts. This enormous disparity is accounted for very simply by the difference in density of the electrons in the two cases. In the vacuum

Table I. Characteristics of Emitters

Cathode Material	A, Amps/Cm² Deg²	b, °K	Operating Temperature, °K	Electron Emission at Operating Temperature: Amps/Cm²	Electron Emission at Operating Temperature: Amps/Watt
Tungsten	60.2	52,400	2500	0.30	0.0043
Thoriated tungsten	3.0	31,500	2000	1.75	0.075
Oxide-coated nickel	0.02	12,000	1150*	0.8	0.15

* This is the normal operating temperature in gaseous rectifiers; oxide cathodes in vacuum operate at approximately 1,050 degrees Kelvin.

Full text of a conference paper presented at the AIEE Winter General Meeting, New York, N. Y., January 30–February 3, 1950.

A. W. Hull is with the General Electric Company, Schenectady, N. Y.

Third in a series of four articles. See "Gaseous-Conduction Phenomena and Their Application in Electrical Engineering" by J. D. Cobine (*EE, June '50, pp 499–504*) and "Mechanism of Spark Breakdown" by L. H. Fisher (*EE, Jul '50, pp 613–19*).

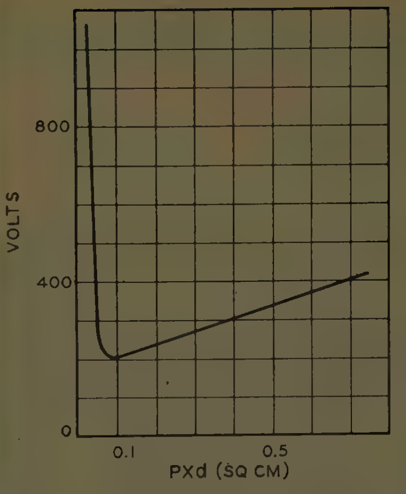


Figure 1 (left). The high-pressure Tungar rectifier has an electron emission from its thoriated-tungsten filament of 100 amperes per square centimeter. (Right). The minimum sparking potential of the gas; this is very close to the arc-back voltage in high-pressure discharges

the electrons are kept far apart by their mutual repulsions. For example, in the vacuum case cited, electrons arriving at the anode would be 1/1000 centimeter apart, far enough to be seen discreetly by the naked eye if they were visible. On the other hand, when positive ions are available, it is possible to pack into the space as many electrons as there are ions, without appreciable repulsion. With such large numbers of electrons, they no longer have to move fast to carry the desired current; hence only a low driving voltage is required. A comparable but extreme case is that of a copper wire, where each atom in the wire behaves like a positive ion with a free electron associated with it. In this case a current of 20 amperes per square centimeter requires a voltage drop of only 30 microvolts per centimeter.

It should be emphasized that the space-charge equations still apply to any excess of electrons or ions in the space. In gaseous rectifiers with low voltage drop, the number of electrons and ions equals about one part in a million.

HIGH-PRESSURE DIODES, TUNGAR

The oldest and simplest gaseous diode is the Tungar rectifier (Figure 1), which was first produced in 1915, and still is standard equipment for charging batteries. As its name indicates, it consists of a tungsten filament in argon gas. The high argon pressure, between five and ten centimeters of mercury, is responsible for the three most important characteristics of the Tungar, namely:

1. Large electron emission.
2. Low voltage drop.
3. Low arc-back voltage.

Gas-Enhanced Electron Emission. The electron emission from the thoriated-tungsten filament in the Tungar is more than ten times that which is obtainable in vacuum or low-pressure gas. The reason is that the argon-gas atmosphere inhibits evaporation, as in the gas-filled lamp, thus allowing the filament to operate at a higher temperature without appreciable loss of tungsten or of thorium, and hence to yield a higher electron emission. There is evidence, also, that the thorium atoms which try to evaporate are ionized by contact with excited argon atoms and driven back to the filament by the electric field, thus maintaining the thorium coating.

Abnormal Low Voltage Drop. The Tungar has an abnormally low voltage drop, about five volts, which is only one-third of the ionizing potential of argon. In order to ionize an atom by impact, an electron must have a minimum amount of energy. The voltage needed to impart this energy to the electron, called the ionizing potential, is different for each gas; for argon it is 15.4 volts. Normally, a gaseous discharge must have a voltage drop between cathode and anode at least as high as the ionizing potential in order to have any ions.

There are three processes capable of yielding an abnormal voltage drop lower than the ionizing potential. The first is oscillation.[3] The voltage drop oscillates at a high frequency, spending a certain amount of time at a value slightly higher than the ionizing potential to produce a supply of ions, then falling to a much lower value until this supply is used up. The time average of these two states usually is less than the ionizing potential and is the voltage drop read on a d-c voltmeter. This process is a very common one, especially in low-current arcs.

The second process is cumulative ionization.[4] The atoms are first excited to a radiating state by an impact less than the ionizing value, for instance, 11.5 volts in the case of argon, and then are given the additional energy needed for ionization by a second impact. A high density of excited atoms is needed to make the second impact probable; it is favored by large current density, high gas pressure, and long life of the excited state. The long life is achieved in some gases by transition to a metastable state; in others by absorption of the radiation by neighboring atoms which in turn become excited. This type of low voltage drop is observed in nearly all monatomic gases when the current and pressure are large enough but does not occur in molecular gases.

The third mechanism by which the voltage drop is lowered is a reverse voltage gradient between the region close to the cathode and the anode.[5] The cathode in this case is surrounded by a very dense cloud of ionization, and the gradient in ion density between cathode and anode produces the reverse voltage gradient. This process is especially marked in argon, partly because of the abnormally long free path of slow electrons in this gas. For example,[5] in an argon tube with tungsten filament, the potential, with respect to the filament, of the ionized plasma around the filament was found to be close to the radiating potential, 11.5 volts, while the anode potential was only 5.2 volts.

All three of these abnormal processes are exemplified in the Tungar rectifier. In a typical test, made by J. D. Cobine in the General Electric Company laboratory, oscillations were found to be present whenever the current was less than one ampere, both in d-c operation and at the beginning and end of each cycle of a-c operation. The voltage drop for this condition was about eight volts. For all currents greater than 1.1 amperes, whether direct or

alternating current, oscillations were entirely absent, and the voltage drop was between 5 and 5.6 volts. This high-current low-voltage-drop state is accounted for by cumulative ionization and large negative voltage gradient.

Arc Back in High-Pressure Gas. The third feature exemplified in the Tungar is the abnormally low arc-back voltage in high-pressure discharges. The arc-back voltage in such discharges is not the normal breakdown voltage corresponding to the pressure and electrode spacing, but a value close to the minimum sparking potential of the gas. This surprising fact may be understood by reference to the curve in Figure 1. The sparking potential in any gas depends on the product of pressure and distance between electrodes, and above a certain minimum it increases uniformly with this product. For electrodes one centimeter apart in argon at a pressure of 7.5 centimeters of mercury, the sparking potential is several thousand volts. The minimum value of about 200 volts* would be obtained if the electrode spacing were reduced to 0.015 centimeter.

It might be expected that the arc-back voltage of the Tungar would be the high value that corresponds to the 1-centimeter spacing. But at the end of the conducting period, when the anode goes negative, the space between cathode and anode is filled with a plasma of ions and electrons; the effective distance then is not one centimeter but the thin sheath[6–8] between the plasma and the negative electrode (anode). This plasma is held at the potential of the positive electrode (filament) by the high mobility of the electrons, so that the whole voltage drop between the electrodes is concentrated in the sheath. In the case of the high-pressure Tungar, the sheath thickness just after conduction is very small, less than the value that would give a minimum sparking voltage. It grows thicker with time, by diffusion of ions to the anode, but very slowly, because the high gas pressure interferes with the diffusion. Hence, at the time of maximum inverse voltage, there is some part of the anode where the sheath thickness is close to the optimum for sparking at the minimum voltage.

Grid Control in High-Pressure Gas. One additional limitation of the Tungar, which is related to the low arc back, is likewise chargeable to the high gas pressure. This is the fact that the starting of the arc cannot be controlled by a grid at frequencies as high as 60 cycles, because of the very long deionization time. The high pressure impedes the motion of the ions so that they do not have time to diffuse to the walls during negative anode voltage.

Thus the Tungar is indebted to high gas pressure for its two main advantages, namely, efficient electron emission and low voltage drop; and also for its two chief limitations, low arc-back voltage and lack of grid control.

This discussion has been devoted to the Tungar, not because of its importance, but because it embodies several of the important processes of gaseous rectifiers.

LOW-PRESSURE DIODES, PHANOTRON

It was recognized very early that the limitations of the Tungar rectifier, particularly the low arc-back voltage, were due to the high gas pressure, and many efforts were made to use low pressure. All of these early attempts resulted in short life; the impact of the positive ions sputtered off the surface of the cathode, so that its electron emission soon was lost. It was assumed that sputtering was necessary with ion impact in low-pressure discharges.

Disintegration Voltages. The solution to this problem was the discovery[9] that this disintegrating effect of the ions does not occur when their energy is less than a certain critical value, called the disintegration voltage. For argon and mercury the disintegration voltage was found to be about 20 volts. Since the ionization potentials of these gases are considerably lower than this value, namely 15.4 and 10.4 volts respectively, an ample supply of ions can be obtained easily without exceeding the disintegration voltage. In fact, the voltage drop, which is a measure of the ion energy, automatically adjusts itself to a value only slightly above the ionizing potential when sufficient gas pressure and field-free electron emission are provided. It was found that a large enhancement of electron emission may be obtained by the strong electrostatic fields accompanying a high voltage drop, and that the disintegration observed in early tests was due to this enhanced emission.

Heat-Shielded Cathode. The field-free emission necessary for low voltage drop is essentially the same as vacuum emission. Obviously, a more efficient source of electrons is desirable for power applications. An excellent solution to this problem is heat-shielding[9] (see Figure 3). A large electron-emitting surface, in the form of vanes or foil, is enclosed in a heat shield consisting of several layers of thin metal foil. Holes or openings are provided for the exit of electrons. In this way one obtains easily a 70-fold reduction in heat loss per unit of electron-emitting area. Obviously, this method of reducing heat loss is not applicable in high-vacuum tubes where the current is limited by space charge.

Gas-Limited Current, Surges. The current that can be carried with a given voltage drop in a low-pressure gas discharge is proportional to the density of electrons, and hence of ions. It is obvious that a limit will be reached when all the available atoms in any cross section of the discharge path are ionized. As this state is approached,

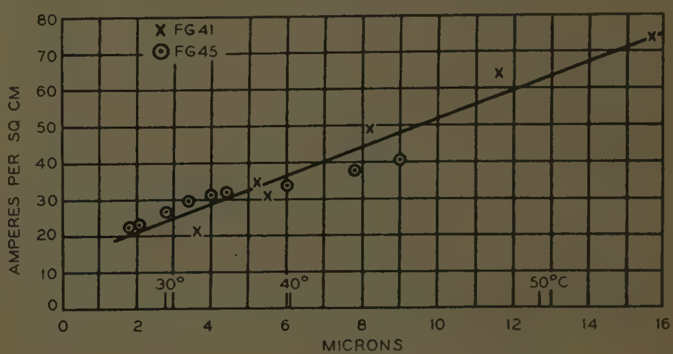


Figure 2. Maximum current capacity of mercury vapor. The extrapolated maximum for 60-degree centigrade mercury (0.026 millimeter of mercury pressure) is 100 amperes per square centimeter

* This is an average value for technically pure argon; lower values are obtained with very pure argon or a combination of argon and mercury.

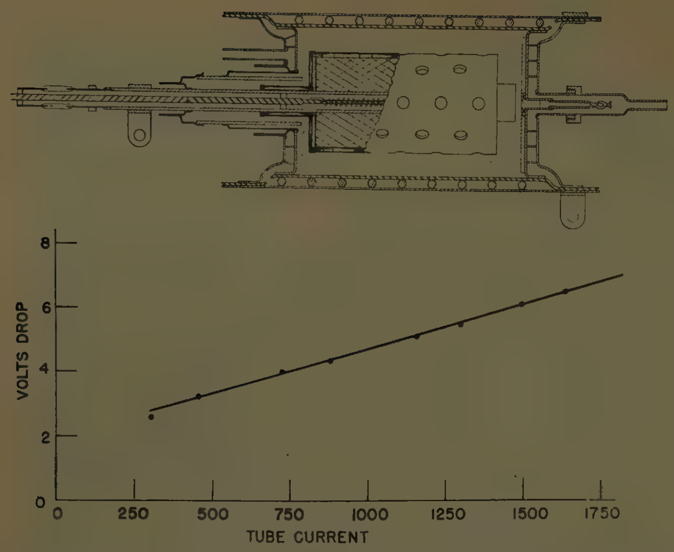


Figure 3 (top). Experimental 200-ampere caesium rectifier. The heat-shielded cathode has an electron emission of 20 amperes per watt. (Bottom). Voltage drop versus peak current in the caesium rectifier

the voltage drop first rises; then with a further slight increase, the discharge becomes unstable. Several factors contribute to this instability.[10] A somewhat oversimplified picture of the process is that the strong field drives the ionized atoms to the walls, depleting the supply of atoms; this causes a further increase of voltage drop and further depletion. The result is a runaway process that leaves the space momentarily almost gas-free, interrupting completely the flow of current. The ionized atoms soon lose their charges at the walls and return to the space, and atoms from adjoining spaces rush in, with a time constant between 10^{-6} and 10^{-5} second, depending on dimensions; and the process repeats itself.

In this sudden cut-off of the current the whole magnetic energy of the current is transformed into electrostatic energy between the electrodes, resulting in high voltage surges, which recur at a random high frequency. Usually the rectifier acts as its own surge arrester by formation of a cathode spot and metal-vapor arc between electrodes, but high voltages may occur which are capable of breaking down transformer insulation. Power rectifiers usually are protected against surges by capacity-resistance shunts.

The maximum current-carrying capacity is defined as the value just short of surges; it has been determined[11] for a number of different types of mercury-vapor rectifiers, with fairly good agreement. Typical results are shown in Figure 2. It is seen that the maximum current-density is 60 amperes per square centimeter at 50 degrees centigrade (0.013 millimeter of mercury). This is the optimum control temperature for high-voltage rectification. At 60 degrees centigrade (0.026 millimeter of mercury), which is the highest practical temperature for most applications, the extrapolated maximum current is 100 amperes per square centimeter.

Arc Back in Low-Pressure Gases. K. H. Kingdon[12] has shown that arc backs in low-pressure rectifiers may be explained as a result of the charging-up of small insulating particles on the anode by positive ions. Such particles are dislodged inevitably from structural insulators and cathode coatings and carried in the convection stream to the anode. When the particles are charged sufficiently to produce a field of about 10^6 volts per centimeter, runaway field emission leads to a cathode spot and arc. Kingdon found that the number of ions needed to produce this effect is between 5 and 12, the smaller number being sufficient with an unaged anode, which has a plentiful supply of particles of all sizes, or after the anode has been sprayed with particles by passing a large current. In a normal discharge, the ions available for this nefarious purpose are the residual ions that are left in the space adjacent the anode when it goes negative. The number reaching the anode in a given time is proportional to their density times their rate of travel. For large electrode spacing, and consequent slow deionization, the ion density depends on the maximum current during the cycle and the rate of travel on the voltage gradient in the ion sheath, which is proportional to the fourth root of the anode-cathode voltage; hence the number of arc backs should be proportional to $I_{max}V_{ca}^{1/4}$.

On the other hand, with small anode-grid spacing and not too high pressure, rapid diffusion makes the ion density at the end of the conduction period proportional to the rate of decrease of current, while their velocity may be taken proportional to the voltage; therefore the probability of arc back should be proportional to the product $-V_{ca}dI/dt$. Good correlation with experiment was found for both of these predictions.

Under certain conditions, the charging of insulating particles and consequent arc formation may be produced by other means than left-over ions; for example, by ultraviolet light [13,14] or glow discharge.[15] In a study of the phase of arc back,[16] it was found that all arc backs occurred immediately after commutation when residual ions were present; but when time was allowed for deionization, the arc backs were distributed throughout the negative anode period on a voltage-dependent basis, indicating glow discharge as the means of charging the particles.

THYRATRON[17]

A GRID between cathode and anode of a phanotron may be used to control the starting of the arc, but cannot control the magnitude of the arc current. The ability to control starting is obvious when it is remembered that in the absence of ions the thyratron is like a vacuum triode, which may be biased beyond cut-off, thus preventing any flow of current and hence any ionization. If now the grid is made positive enough to allow a small fraction of a milliampere of electron current, ionization starts and the current builds up rapidly to full value, usually in a few microseconds. This current cannot be stopped by again making the grid negative but will flow as long as the anode voltage is maintained.

Phase Control. This suggests a method for control of average current with alternating power supply; namely, controlling the time of starting in each cycle. The maximum current obviously is obtained when the current

starts at the beginning of each cycle and flows for the full period of positive anode voltage; the minimum when the starting in each cycle is near the end of this period.

Positive Ion Sheaths. The reason that a negative grid cannot stop an arc discharge is that it is insulated from the discharge by a thin sheath of positive ions.[6–8] If the grid is made negative while current is flowing, it finds itself surrounded by a dense plasma containing equal numbers of electrons and ions. It repels the electrons and attracts the ions. Thus there is a thin space close to the grid which contains only positive ions whose current is limited by space charge. The whole voltage difference between grid and plasma is confined to this sheath. Its thickness is proportional to the three-fourths power of the grid voltage, and varies inversely as the square root of the ion current (equation 3). The ion current is proportional to the ion density in the plasma, being the number of ions that arrive per second by diffusion at the outer boundary of the sheath. Therefore, thin sheaths correspond to dense plasmas and hence large load currents. For all practical load currents and grid voltages, the sheath thickness is a small fraction of a millimeter. Beyond the sheath the grid has no effect.

Deionization Time. Similar sheaths are formed by ions that are left in the space after the discharge stops and may prevent the grid from gaining control of starting. In general, there will be some ions, from the last discharge period, left in the space when the anode voltage again goes positive. If their density is small enough and the grid voltage negative enough to make the sheath thickness greater than half the distance between grid wires, the sheaths will overlap and present a retarding field to the flow of electrons from the cathode; if thinner than this, there will be a field-free space between the sheaths of adjacent wires, which will allow the current to start and build up. The time that must be allowed, after the end of the current period, for the ion density to fall to this critical value is called the deionization time. It depends on several factors, including gas pressure and grid and anode voltages, but most strongly on the distance between grid and anode, and the ion density at the end of the conduction period. When the grid and anode are close, and hence the diffusion of ions to them fast, the ion density is nearly in equilibrium with the load current; under these conditions the density at the end of conduction does not depend on the maximum load current but on its rate of decrease at the end. This is the condition most commonly met with in good rectifier practice; therefore, the rate of decrease of current is an important factor both for deionization and for arc back. This is the basis of Kingdon's criterion for arc back.

Cleanup of Gas. Deionization is the principal factor also in the disappearance of gas in inert-gas thyratrons, which use argon or xenon at 50 to 100 microns pressure. Ions remaining in the anode-grid space when the anode voltage goes negative are driven into the anode to a depth depending on the voltage. There they stick, diffusing out slowly if the depth is not too great, but depleting the supply of gas temporarily, and gradually reducing the pressure unless the recovery rate is equal to the rate of clean-up. The best solution to this problem is rapid deionization, which is accomplished by close anode-grid spacing and complete enclosure. The close spacing speeds up deionization so that the ions are gone before the anode voltage reaches high negative values, thus preventing deep penetration into the anode; it also shortens the deionization time, allowing a higher initial pressure.

Emission and Voltage Drop in Caesium Vapor. A new development of considerable promise is a rectifier or thyratron which substitutes caesium vapor for mercury as the conducting gas and simultaneously makes use of the condensed monatomic layer of caesium as cathode coating (Figure 3). The tube is heated to 150–180 degrees centigrade to give the desired vapor pressure.

The electron emission from a monatomic film of caesium on a metal surface is unique in that the coating is maintained by the process of condensation and evaporation, as an equilibrium condition. Langmuir and others,[18] working at low caesium pressures, showed that the electron emission from tungsten was a maximum when the coating was 0.67 of a monatomic layer, and was consistent with a work function of 1.7 volts.

The emission from a number of metals at vapor pressures up 0.080 millimeter of mercury (corresponding to a caesium temperature of 200 degrees centigrade) has been studied. We find, in agreement with Langmuir and Taylor, that the emission at a given caesium pressure rises to a sharp maximum as the cathode temperature increases, and falls rapidly above this temperature. A Richardson plot of these maxima for caesium on nickel leads to the equation, for zero field emission:

$$i = 460\, T^2 \epsilon^{-\frac{[\text{illegible}]}{T}} \text{ amperes per square centimeter degrees Kelvin squared}$$

This corresponds to one ampere per square centimeter at a caesium temperature of 185 degrees centigrade. By means of heat-shielding (see Figure 3) an emission efficiency of 20 amperes per watt is obtained. An interesting feature of this type of cathode is that its life is unlimited.

Even more interesting is the voltage drop, which is the lowest known (see graph, Figure 3).

Grid control is obtained by a grid made of hollow tubing, allowing temperature control by the same fluid which cools the anode. These tubes are in the experimental stage.

MERCURY-ARC RECTIFIER

The multianode mercury-arc rectifier with holding anode is too well known to need description. Its unique feature is that the current is furnished by an arc issuing from a cathode spot which wanders rapidly and randomly on the mercury surface; moves in the "wrong direction" in a magnetic field, that is, opposite to the direction of the force on the arc column; breaks into multiple spots when more current is demanded, with an average of about 35 amperes per spot; is extinguished if interrupted for as long as 10^{-9} second;[19] and has resisted thus far all attempts to explain its mechanism. Other

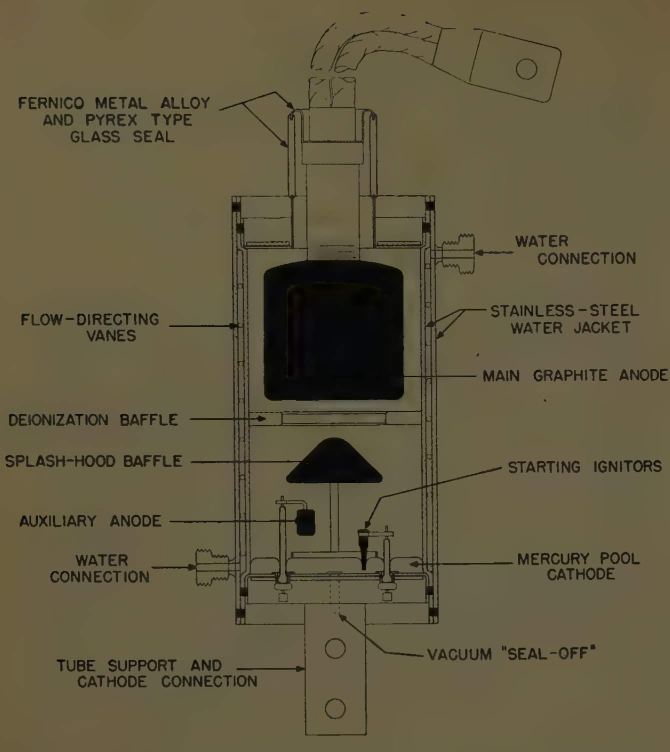


Figure 4. Typical ignitron rectifier, a single-anode rectifier in which the arc is started each cycle by passing a current through a semiconductor the tip of which is immersed in the mercury

combinations have been tried, but mercury has the advantage of returning to the cathode pool after being vaporized, while most of the others stick to the walls.

THE IGNITRON

A GREAT step forward was taken by the invention of the ignitron,[20] a single-anode rectifier in which the arc is started each cycle (Figure 4).

Excitation by Ignitor. The starting is accomplished by passing a current through a semiconductor, such as boron carbide, whose tip is immersed in the mercury. Typical values of ignitor current and voltage for accurate starting are ten amperes at 200 volts.

The mechanism of ignitor operation, like that of the cathode spot in general, is still an unsolved problem. The best present theory is that the voltage gradient in the ignitor produces an electrostatic field between it and the mercury meniscus, just at the point of contact, which is strong enough to cause runaway field emission. This explanation is consistent with the fact that ignitor action is ruined if the mercury wets the ignitor, thus destroying the meniscus. Such wetting may occur when the mercury contains impurities, such as gold, or when the current through the ignitor is reversed. For this reason it is customary to use a rectifier in series with the ignitor, or a thyratron when phase control is desired.

Phase control can be accomplished by varying the time in the cycle at which the ignitor is fired, thus attaining the same result as by grid control. Ignitrons have earned a very important place in the rectifier industry, due mainly to their simplicity of structure and low voltage drop.

Fault-Current Capacity. The ignitron has one useful feature that is not shared by hot-cathode or multianode mercury rectifiers, namely the ability to carry very large currents, of the order of 20 times normal, for a few cycles. These currents are several times larger than would be predicted by the product of cross section and normal vapor pressure. Apparently they are to be explained by an increase in pressure due to the instantaneous conversion of spray into vapor. Since the amount of spray is proportional to current, this gives a momentary increase of vapor density just when and where it is needed. Multianode rectifiers do not share this property because their anode arms are too remote from the spray to profit by the local increase of vapor density.

Series Anodes. The voltage limit of an ignitron may be doubled, trebled, and so forth, by the addition of one, two, or more voltage-dividing grids or intermediate anodes between cathode and anode. Provision is made for electric connection to the intermediate anodes, allowing the use of a resistance voltage divider to maintain equal division of voltage. Under proper conditions, the electrical connection to the intermediate anodes may be omitted; phanotron tubes have been built with 20 or more insulated intermediate anodes.

REFERENCES

1. Electron Emission, **S. Dushman.** *Electrical Engineering*, volume 53, July 1934, pages 1054–62.

2. Electrical Discharges in Gases, **I. Langmuir, K. T. Compton.** *Review of Modern Physics* (New York, N. Y.), volume 3, 1931, pages 237–45.

3. The Abnormal Low-Voltage Arc, **Carl Eckart, K. T. Compton.** *Physical Review* (New York, N. Y.), volume 24, 1924, pages 97–112.

4. Theory of Ionization by Cumulative Action and the Low-Voltage Arc, **K. T. Compton.** *Physical Review* (New York, N. Y.), volume 20, 1922, pages 283–99.

5. The Diffusion of Electrons Against an Electric Field in the Non-oscillatory Abnormal Low-Voltage Arc, **K. T. Compton, Carl Eckart.** *Physical Review* (New York, N. Y.), volume 25, 1925, pages 139–46.

6. Positive-Ion Currents in the Positive Column of the Mercury Arc, **I. Langmuir.** *Science* (New York, N. Y.), volume 58, 1923, page 290.

7. Positive-Ion Currents in the Positive Column of the Mercury Arc, **I. Langmuir.** *General Electric Review* (Schenectady, N. Y.), volume 26, 1923, pages 731–5.

8. Studies of Electric Discharges in Gases at Low Pressures, **I. Langmuir, H. Mott-smith.** *General Electric Review* (Schenectady, N. Y.), volume 27, 1924, pages 449, 538, 616, 762, 810.

9. Gas-Filled Thermionic Tubes, **A. W. Hull.** AIEE *Transactions*, volume 47, July 1928, pages 753–63.

10. Theory and Phenomena of High Current Densities in Low-Pressure Arcs, **L. Tonks.** *Transactions of the Electrochemical Society* (New York, N. Y.), volume 72, 1937, pages 167–82.

11. The Cause of High-Voltage Surges in Rectifier Circuits, **A. W. Hull, F. R. Elder.** *Journal of Applied Physics* (New York, N. Y.), volume 13, 1942, pages 372–7.

12. The Relation of Residual Ionization to Arc Back in Thyratrons, **K. H. Kingdon, E. J. Lawton.** *General Electric Review* (Schenectady, N. Y.), volume 42, 1939, pages 474–8.

13. Thin Film Field Emission, **L. Malter.** *Physical Review* (New York, N. Y.), volume 49, 1936, page 478, and volume 50, 1936, pages 48–58.

14. Visual Observations on the Malter Effect, **L. R. Koller, R. P. Johnson.** *Physical Review* (New York, N. Y.), volume 52, 1937, page 519.

15. Eine Neue Art von Glimmentladung ohne Hittorfschen Dunkelraum und ohne Kathodenfall (in German), **A. Guentherschulze, Hans Fricke.** *Zeitschrift fuer Physik* (Berlin, Germany), volume 86, 1933, pages 451–63 and 821–7.

16. The Phase of Arc Back, **A. W. Hull, F. R. Elder.** *Journal of Applied Physics* (New York, N. Y.), volume 13, 1942, pages 171–8.

17. Hot-Cathode Thyratrons, **A. W. Hull.** *General Electric Review* (Schenectady, N. Y.), volume 32, 1929, pages 213–23 and 390–9.

18. The Evaporation of Atoms, Ions, and Electrons from Caesium Films on Tungsten, **I. Langmuir, J. B. Taylor.** *Physical Review* (New York, N. Y.), volume 44, 1933, pages 423–57.

19. Uber die Loeschung des Lichtbogenbrennflecks an einer Quecksilberkathode (in German), **G. Mierdel.** *Zeitschrift fuer Technische Physik* (Leipzig, Germany), volume 17, 1936, pages 452–5.

20. A New Method of Initiating the Cathode of an Arc, **J. Slepian, L. R. Ludwig.** AIEE *Transactions*, volume 52, June 1933, pages 693–8.

Special Purpose Batteries

ADOLPH FISCHBACH

Standard-type primary and secondary batteries are unsatisfactory for certain types of Army and Air Corps equipment and, consequently, special purpose batteries suitable for these particular applications had to be developed. This article* describes three systems which have been found to be the most effective at the present time.

As the Signal Corps was given the general responsibility for supplying primary battery power for specialized types of equipment for the Army and Air Corps, it was necessary to set up a program which would arrive at an interim solution to some of these applications, as well as a long-term research and development program which would result in a standard line of special purpose batteries suitable for such applications. Because of the demand for high discharge rates, high capacity per unit of volume and weight, and other stringent requirements, it was soon recognized that the standard-type primary and secondary types of batteries would be unsatisfactory for these special applications.

One of the first steps in the development of a line of batteries for these applications was to set up general specifications based on a review of all application requirements which had been received.

Obviously, an extensive program of research and development had to be carried on if batteries were to be developed which would give optimum performance in line with these stringent requirements. The Battery Branch of the Signal Corps Engineering Laboratories has been active for some time in this type of investigation, both through internal laboratory work and by contractual activity. Information obtained on experimental contracts, such as those with the universities, industry, and research laboratories, is also being utilized in the solutions of these problems.

Of necessity, numerous electrochemical systems and designs were considered and preliminarily investigated in order to select systems which were considered the most promising at this time. Considerable progress has been made to date on this activity. Studies have been and are being made on the characteristics of battery electrode materials as well as on the development of designs to give the desired performance characteristics. In addition to finding an interim solution to some of these problems, these laboratories have for some time been carrying on a long-range program to cover this special application field. A complete report on all of the investigations cannot be given at this time.

However, some of the highlights of the systems and designs which to date have been found to be the most effective interim solution to specific application problems will be presented. The systems which will be discussed are: the magnesium, water, cuprous-chloride system; the zinc, potassium-hydroxide, silver-peroxide system; and the cadmium, acid, lead-peroxide system.

Of the three afore-mentioned systems, the magnesium, water, cuprous-chloride system seems to offer the best solution for some of the specialized applications, particularly those where the battery has to be stored for long periods of time; where the battery has to be easily activated at the time it is required for operation; where the power can, or will, be used within a comparatively short time after activation; and where the capacity required per unit of weight and volume is exceptionally high. The battery must, of necessity, be activated at more or less normal temperatures (above the freezing point of water). Since heat is generated during the course of the discharge, this system can be utilized in powering equipments going into cold temperatures, if the proper heat balances are maintained.

Examination of its characteristics indicates that the magnesium, water, cuprous-chloride system should be capable of meeting the cold temperature conditions indicated above. For this reason, much emphasis has been placed on the utilization of this system for such applications.

Work on the development of the magnesium, water, cuprous-chloride system was first started in the early part

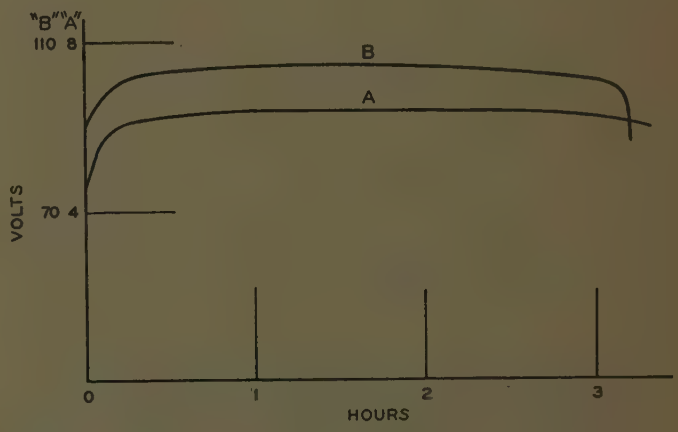


Figure 1. Discharge of dunk-type magnesium cuprous-chloride meteorological battery. The A unit was discharged through 28.4 ohms, and the B unit was discharged through 3,833 ohms. The battery was discharged for five minutes at 80 degrees Fahrenheit and at −58 degrees Fahrenheit for the remainder of the time

* Third in a series of three articles on batteries. The first was "Primary Batteries," C. H. Clark (*EE, June '50, pp 515–18*), and the second was "Military Storage Batteries," Hyman Mandel (*EE, Jul '50, pp 619–21*).

Adolph Fischbach is with the Signal Corps Engineering Laboratories, Fort Monmouth, N. J.

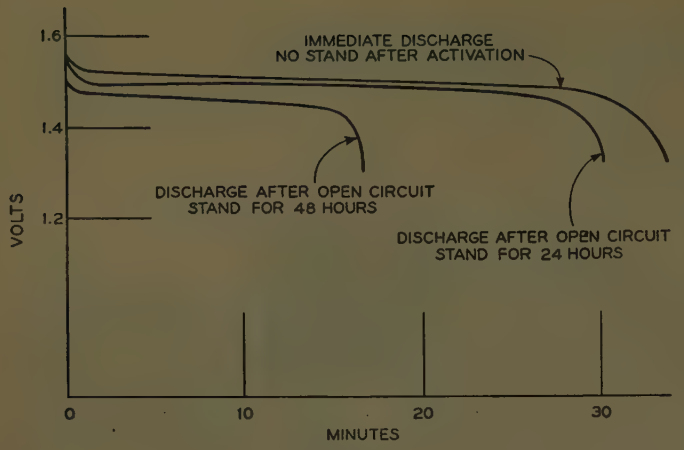


Figure 2. Discharge characteristics of zinc, potassium-hydroxide, silver-peroxide cells after various stand periods after activation. Discharges were at 20 amperes and 80 degrees Fahrenheit

of 1946. Early tests had indicated its possibilities as a relatively inexpensive high-capacity battery. Although the system was first thought to be impractical for battery applications due to its initial self-discharge and evolution of heat, the Signal Corps, by continued effort in its Engineering Laboratories, developed a practical operating cell. Then through co-ordinated effort with the battery industry, this cell was developed into a practical battery, utilizing the so-called "dunk" construction, a design where the cells are individually wrapped and joined externally by a series of welds. The tops and bottoms of the cells are left open. This battery at the present time meets some of the special application requirements demanded by the various services.

Figure 1 shows a curve of specification discharges carried out on one of these batteries. The battery was activated by dunking in an electrolyte of water containing 1-per cent cadmium chloride and 1/4-per cent ammonium chloride, then shaken to remove excess electrolyte. It was discharged for five minutes at 80 degrees Fahrenheit and then placed in the −58-degree-Fahrenheit cabinet for the remainder of the run. As can be seen from this figure, the discharge curve of both the *A* and *B* sections is exceptionally flat and uniform.

A 108-volt *B* and 6-volt *A* supply, draining approximately 30 milliamperes on the *B* and 250 milliamperes on the *A*, weighs approximately 400 grams when activated and gives, on this type of discharge, approximately 20 watt-hours per pound. The battery has proved in field tests to be very satisfactory in operating equipment at high altitudes. Another advantageous feature is price. It is expected that this battery in production will be cheaper than other types of batteries that have been considered for this application.

It is not believed, however, that the present battery is the ultimate that can be obtained for this type of application and further development work is continuing to improve the design and characteristics. This development is proceeding along the lines of a "pile"-type battery since it is believed that such a battery would be easier to construct. Basically, the construction of this battery involves stacking in succession positives, separators, magnesium, and copper plates and repeating the operation to the desired number of cells and voltage. The edges are then sealed to prevent short-circuiting between cells. By properly sealing and protecting the edges of the plates, the copper sheet acts as a partition between cells and also as a metallic conductor in conducting the current from one cell to the next.

Tests already conducted on the "pile"-type battery have shown very favorable results. It is expected that the success of this development will effect a considerable saving in manufacturing cost.

The second of the three systems previously mentioned, the zinc, potassium-hydroxide, silver-peroxide system, offers certain advantages not found in the magnesium, water, cuprous-chloride system for certain applications. These might be listed as its ability to stand for comparatively long periods of time after activation without seriously impairing the capacity of the battery, its property of not overheating on comparatively high-rate discharges, and of being relatively free from gassing on discharge. In the present state of development, however, the battery is not satisfactory for high-rate discharges below 0 degrees Fahrenheit. Some preliminary investigations, which will be described later in this article, have indicated the possibility of good low-temperature performance of this type of battery.

Because of the properties of this system, it has proved very satisfactory for some high-rate applications. One battery which utilizes this system was designed at the Signal Corps Engineering Laboratories and is presently being produced by one of the battery companies. This is a 9-cell battery weighing slightly over $7^1/_2$ pounds activated. The inside dimensions of the individual cells in this battery are approximately 3/4 by $2^{13}/_{16}$ by $4^1/_2$ inches. Each cell contains 17 plates; eight positives and nine negatives. These plates are $2^1/_2$ inches by $3^1/_2$ inches. The anode is corrugated zinc sheet approximately six mils thick. The cathode is silver peroxide supported on a suitable screen grid and is 12 to 15 mils thick. Each cell contains approximately 85 milliliters of potassium hydroxide. Each plate is separately wrapped in 4- to 5-mil

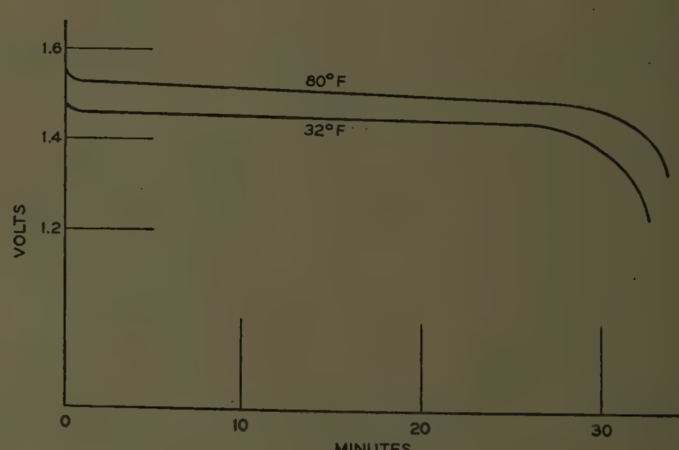


Figure 3. Effect of temperature on the discharge characteristics of zinc, potassium-hydroxide, silver-peroxide cells. Discharges were at 20 amperes

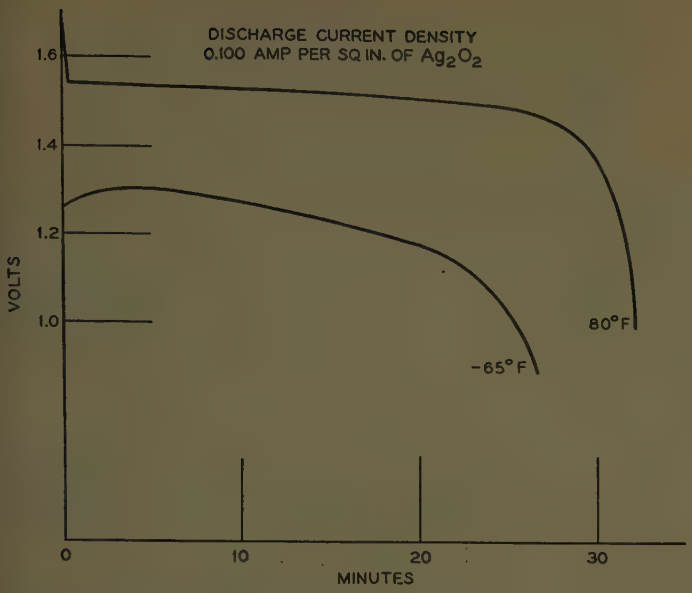


Figure 4. Discharge characteristics at different temperatures of sponge-zinc, potassium-hydroxide, silver-peroxide experimental 3-plate cells

thickness absorbent paper. In this battery each cell weighs about 0.85 pound.

The curves in Figure 2 show the discharge characteristics of one of these cells when discharged at 80 degrees Fahrenheit at the 20-ampere rate. The top curve gives the discharge immediately after filling the battery, the middle curve gives the discharge after a 24-hour stand at 80 degrees Fahrenheit, and the lower curve shows the discharge characteristics after the cell has stood for 48 hours at 80 degrees Fahrenheit. The maximum stand period that can be tolerated with this design and construction is about 24 hours at 80 degrees Fahrenheit. At the 20-ampere discharge rate, the current density of this cell is approximately 140 milliamperes per square inch of positive plate surface and the battery delivers about $17^1/_2$ watt-hours per pound. This figure could probably be improved if a concerted effort were made to reduce the case weight.

Figure 3 shows the effect of temperature. The top curve is a discharge at 80 degrees Fahrenheit at the 20-ampere rate, the lower curve is a discharge at 32 degrees Fahrenheit at the same rate. The average discharge voltage is lowered about 0.06 volt due to this change in temperature. Other work not shown here indicates that very low capacities are obtained from this cell at 0 degrees Fahrenheit when discharged at the 20-ampere rate.

As stated before, this particular battery has proved effective in a number of applications for operation above 0 degrees Fahrenheit and has actually been assigned to several equipments. One drawback to batteries using this system is that the cathode is made of silver and, since silver is a rather expensive metal, it is expected that batteries employing this system will be costly. Therefore, the end use of these batteries must justify the expense of a high-cost battery.

Further work is being done to improve the characteristics of this type of battery. Much remains to be done to obtain a separator which will allow the battery to stand in an activated condition for long periods of time without seriously affecting its capacity because of self-discharge. The Signal Corps Engineering Laboratories have recently done preliminary work on a sponge-zinc anode which allows these batteries to discharge at moderately high rates at temperatures as low as −65 degrees Fahrenheit. This may possibly solve some of the low-temperature problems.

Figure 4 shows the results obtained on an experimental cell. This cell had one positive and two negative plates. The positive plate was the usual type while the negative plate was a sponge-zinc plate which had high porosity and surface area. Both the positive and negative plates were $1^1/_2$ by $2^1/_2$ inches by approximately 20 to 25 mils in thickness. The inside dimensions of the cell were approximately 1/4 by $1^3/_4$ by 3 inches. The electrolyte was 14 milliliters of 31.5-per cent potassium hydroxide. There were no separators. The plates were, however, held about 0.060 inch apart by supporting the plates in slots cut in the edges of the cell case. These cells were discharged at 750 milliamperes at both −65 degrees Fahrenheit and 80 degrees Fahrenheit. This was equivalent to an apparent current density of 100 milliamperes per square inch of positive plate surface. At this discharge rate, capacities approaching those obtained at 80 degrees Fahrenheit were obtained at −65 degrees Fahrenheit. There was, however, a voltage drop of approximately 0.2 volt at the low temperatures and the slope of the curve was not nearly as flat at −65 degrees Fahrenheit as at 80 degrees Fahrenheit. This is a marked improvement over any other type of zinc anode tested since all other types of anode gave zero capacity at −65 degrees Fahrenheit at this drain. All of this sponge-zinc work is very new and still requires considerable exploration before the complete operating characteristics of these batteries, particularly at low temperatures, can be determined.

The third of the three systems previously mentioned, the cadmium, acid, lead-peroxide system, offers certain properties which seem to overcome, to some degree, the difficulties encountered with some of the other systems.

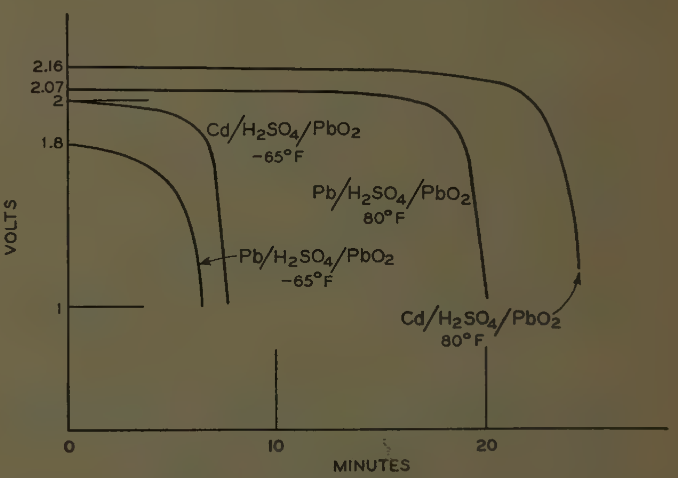


Figure 5. Comparison of discharge characteristics at different temperatures of sponge-cadmium, lead-peroxide and sponge-lead, lead-peroxide cells with sulfuric acid-electrolyte. Discharge current density was 0.100 ampere per square inch of lead peroxide

The exceptionally good low-temperature results which have been obtained on this system have been due primarily to the sponge-cadmium negative recently developed at the Signal Corps Engineering Laboratories. The utilization of this sponge-cadmium negative allows for instantaneous activation at temperatures as low as −65 degrees Fahrenheit if the proper acids are used. It also allows for effective utilization of the capacity obtainable from the cell without the necessity of charging, which is generally necessary with the dry-charged sponge-lead plate after it has stood in air for any length of time. Also, the discharge voltage is generally higher when cadmium is used in place of lead.

Because of the properties of this system, it has proved extremely satisfactory for several high-rate applications. In fact, it is the only system which up to the present time was found to be capable of satisfactory operation in those particular applications which require instantaneous availability of power from a dry charged battery upon activation with electrolyte at −65 degrees Fahrenheit.

Since the sponge-cadmium negative is a recent development, there is not much information available on its characteristics at this time. All of the test data being used today were obtained on 3-plate cells containing one positive and two negative plates. These plates and cells were the same size as the experimental cell used for the zinc silver-peroxide studies. The electrolyte was 12 to 14 milliliters of 1.280-specific-gravity sulfuric acid. There were no separators. The plates were held about 60 mils apart by supporting slots in the sides of the cells. The anode was of sponge cadmium supported on a suitable screen grid; the positive plate was of lead peroxide, also supported on a suitable screen grid.

Figure 5 shows the discharge curve of this cell when discharged at 80 degrees Fahrenheit and −65 degrees Fahrenheit at 100 milliamperes per square inch in comparison with a sponge-lead anode cell made in the same manner as the cadmium cell. The cadmium cell here was activated and discharged immediately. It was found during the course of the work that very poor results would be obtained from the lead-acid cell unless it was charged prior to discharge. At 80 degrees Fahrenheit, the average discharge voltage of the cadmium cell was approximately 0.1 volt higher than that of the lead cell and at −65 degrees Fahrenheit it was approximately 0.2 volt higher than that of the lead cell. In every case, the capacity of the cadmium cell was greater than that of the lead cell.

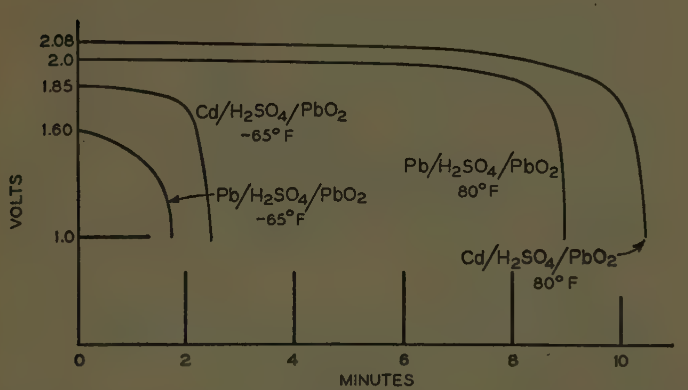


Figure 6. Comparison of discharge characteristics at different temperatures of sponge-cadmium, lead-peroxide and sponge-lead, lead-peroxide cells in sulfuric-acid electrolyte. Discharge current density was 0.250 ampere per square inch of lead peroxide

Figure 6 shows the comparison of the same type of cadmium and lead cell when discharged at 80 degrees Fahrenheit and −65 degrees Fahrenheit at a current density of 250 milliamperes per square inch. The characteristics there are similar to those of the preceding curve, shown in Figure 5.

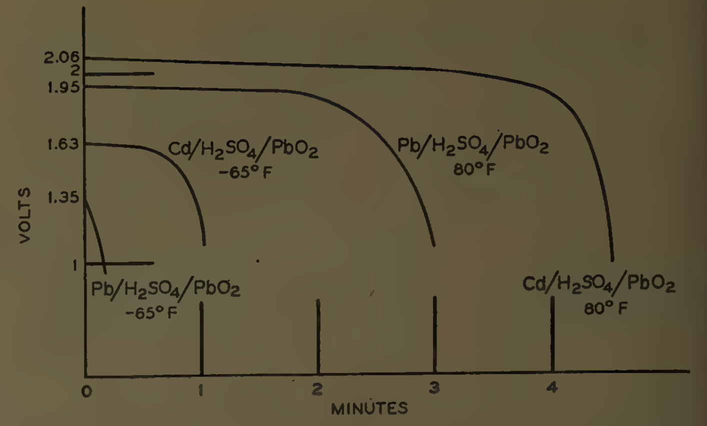


Figure 7. Comparison of discharge characteristics at different temperatures of sponge-cadmium, lead-peroxide and sponge-lead, lead-peroxide cells in sulfuric-acid electrolyte. Discharge current density was 0.500 ampere per square inch of lead peroxide

Figure 7 shows the discharge characteristics of these two types of cells when discharged at 80 degrees Fahrenheit and −65 degrees Fahrenheit, at a current density of 500 milliamperes per square inch. The differences between the curves are more exaggerated at this high rate showing that the lead cell is beginning to fall off very rapidly.

From a study of the information which is already available on the cadmium, acid, lead-peroxide system, it appears that this couple will be useful where quick activation, high-rate discharges at low temperatures, and good activation-stand characteristics are required. It therefore appears that this system warrants further investigation.

In conclusion, the work which has been discussed here only briefly describes the progress that has been achieved and the extent of the program on electrochemical systems and battery designs for special purpose applications. Other systems have also been investigated and still need further investigation as do the systems already discussed. For the purpose of this article, the three systems which to date have shown the most immediate promise in fulfilling certain special requirements for battery power supplies were discussed. Because of the many varied requests for special purpose batteries for the Air Corps and the Army, it is necessary that the long-range investigational program be as extensive as possible. It is hoped that from this program, there will ultimately be obtained a standard line of electrochemical power supplies of the *A* and *B* battery type, which will be capable of satisfying all of the stringent requirements demanded by the services of special purpose batteries and which can be set up on an off-the-shelf basis.

Indicating Instruments at Servo Frequencies

W. S. PRITCHETT
ASSOCIATE AIEE

R. M. SAUNDERS
MEMBER AIEE

WITH THE advancing application of sinusoidal analysis to servo systems, the need has arisen for instruments that will measure a-c steady-state quantities in the frequency range of usual servo operation, either by use of conventional portable instruments or by the development of new instruments. At the present time the oscillograph and oscilloscope are the most commonly used tools in the analysis of servo systems. If the indicating instrument could be used, it would eliminate analysis of oscillograms.

Most commercial indicating instruments are designed for optimum performance in the range from 25 to 133 cycles per second. As the frequency applied to the terminals of such instruments is reduced, the behavior of the instrument is characterized by three zones: zone *A*—where the pointer remains motionless or has a small excursion on either side of the average deflection; zone *B*—where the pointer follows the impressed wave without amplitude or phase-angle error; zone *C*—the zone lying between zones *A* and *B*.

In most instruments zone *A* extends downward from the power frequencies, and the readings represent the effective values of the impressed wave, while zone *B* extends upward from zero frequency or direct current, and the maximum reading of the instrument represents the maximum value of the wave. Either zone *A* or *B* operation of the instrument will result in reliable indications of either the maximum or the effective value of the wave in question. Zone *C* operation is completely unreliable. Frequently a-c instruments which have a low stated error on direct currents give a larger deflection on one half than on the other half of the cycle when used in zone *B*, but the average of the two maximum readings usually can be used.

The amplitude response-versus-frequency characteristic of a given instrument will provide one with the information needed to determine where the various zones lie. The per unit change in scale reading is defined as the ratio of the actual change in reading to the reading corresponding to the maximum value of the impressed electrical quantity. When the per unit change in scale reading is unity, the instrument is following the impressed wave precisely without amplitude error, as described for zone *B*. As the frequency of the impressed wave increases, although the amplitude remains constant, the per unit response begins to fall off until the per unit change in reading becomes very small, within five per cent; this is defined as the beginning of zone *A* which then extends upward to the power frequencies. Figure 1 shows the amplitude-response characteristics of several conventional instruments and a special low-frequency electrodynamometer instrument when subjected to a constant-amplitude varying-frequency voltage.

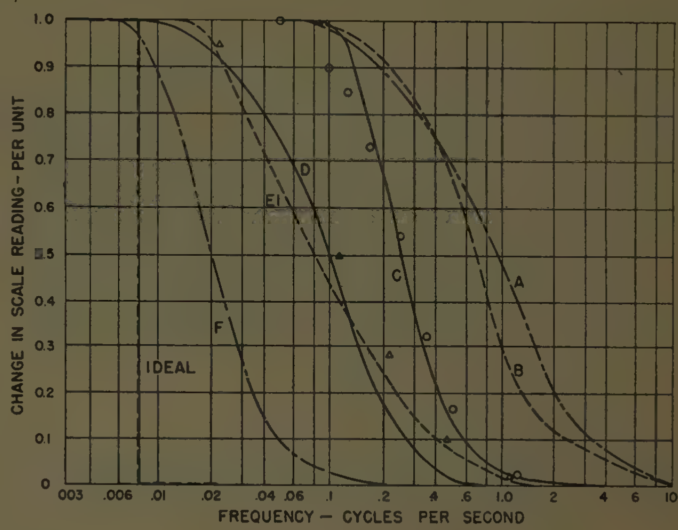


Figure 1. Amplitude response-versus-frequency characteristics for conventional instruments, the ideal instrument, and the low-frequency instrument

Curve A—Permanent-magnet moving coil
Curve B—Full-wave rectifier
Curve C—Electrodynamometer
Curve D—Thermocouple
Curve E1—Moving vane (radial scale)
Curve F—Low-frequency electrodynamometer
Computed points for curve C are shown as circles while the triangles are for E1

Modifications to existing instruments for extending zone *A* downward may take the form of increasing the damping, the moment of inertia, or decreasing the spring constant. Heavy damping results in a very slow transient response, and the other two modifications lead to mechanical difficulties. An instrument overcoming these objections and employing commonly available springs, pivots, and jewels, but floated in an insulating fluid, has been constructed. The amplitude-versus-frequency characteristic of this instrument is shown as curve *F*, Figure 1, and the time constant was 7.5 seconds.

After investigation, these conclusions were reached:

1. The electrodynamometer instrument damped to the slightly oscillatory condition gives the narrowest zone *C*.
2. When zone *B* operation can be sacrificed, and a long time constant can be tolerated, zone *A* operation can be extended by heavy damping of conventional instruments.
3. Increasing the moment of inertia and decreasing the spring constant is not feasible in conventional instruments.
4. An instrument designed with a large natural period and proper damping affords the opportunity of bridging the zones where conventional instruments are unreliable.

Digest of paper 50-155, "Indicating Instruments at the Servomechanism Frequencies," recommended by the AIEE Committee on Instruments and Measurements and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer and Pacific General Meeting, Pasadena, Calif., June 12–16, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

W. S. Pritchett and R. M. Saunders are with the Division of Electrical Engineering, University of California, Berkeley, Calif.

The authors wish to express their appreciation to F. F. Davis for his many contributions to the design and construction of the low-frequency instrument described in the article.

Lightning Performance of 287.5-Kv Hoover Dam–Los Angeles Transmission Lines

T. M. BLAKESLEE
FELLOW AIEE

E. L. KANOUSE
MEMBER AIEE

During the 13 years that the 287.5-kv transmission lines from Hoover Dam to Los Angeles have been in operation many records of lightning performance have been made. This article presents a summary of the data which have been obtained during the period and describes the methods and instruments used for measuring and recording.

THIS ARTICLE presents the lightning performance data that have been accumulated on the 287,500-volt Hoover Dam-to-Los Angeles transmission lines over the first 13-year period these lines have been in operation. The design data for these circuits have been presented to the Institute[1], and a comparison with other high-voltage lines in the United States on features pertinent to lightning performance will be found in an AIEE committee report presented in 1946.[2]

Figure 1 shows a standard single-circuit suspension tower and indicates the dimensions pertinent to lightning performance. Figure 2 presents the general geographic layout of the three transmission circuits, their terminals, and switching stations.

The line passes from cultivated land around Los Angeles through valleys, foothill sections, mountain ranges, and long stretches of desert to Hoover Dam. The line elevation varies from practically sea level to a maximum of 4,862 feet to give an average of 2,400 feet. The isokeraunic level varies from 30 near Hoover Dam to approximately 5 for the Los Angeles vicinity. The heaviest lightning season for the lines is during the summer and early fall.

USE OF LIGHTNING-RECORDING DEVICES

THE performance data are obtained through the medium of four types of lightning-recording equipment:

1. Counterpoise gaps[1] are installed on three legs of the Victorville-Receiving Station *E* section and on all four tower legs of the remainder of the line. These gaps, installed primarily to prevent corrosion, have proved a reliable means for recording lightning data. They are used to determine the comparative intensity and probable number of lightning strokes on the line. Figure 3 shows the two types of gaps used.

2. Magnetic links (surge-crest ammeters[3]) are installed at select locations along the line totalling 30 miles, where lightning storms are prevalent.

3. Surge recorders with paper indicators are installed on all lightning arrestors at the terminals of the lines. While these offer a positive indication of current discharge, they are not accurate for estimating current values. The lightning arresters are equipped also with the magnetic links.

4. Copper lightning rods in series with fusible copper wires together with magnetic links are used on the lightning-diverter towers at the Hoover Dam terminal and at the intermediate switching stations. These rod and fuse

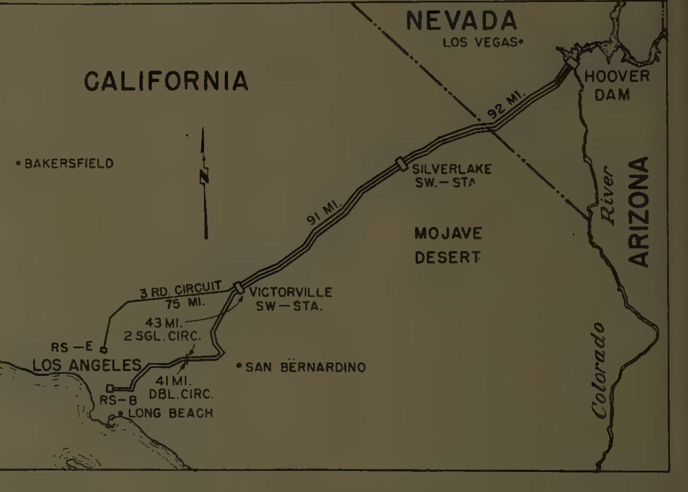


Figure 2. Map showing the geographical location of Boulder transmission lines

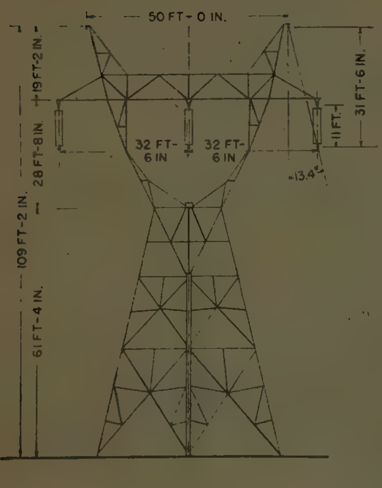


Figure 1. Standard single-circuit suspension tower showing the dimensions influencing lightning performance

Full text of paper 50-130, "Thirteen-Year Lightning Performance of Boulder 287.5-Kv Transmission Lines," recommended by the AIEE Committee on Transmission and Distribution and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer and Pacific General Meeting, Pasadena, Calif., June 12–16, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

T. M. Blakeslee and E. L. Kanouse are with the Department of Water and Power, The City of Los Angeles, Los Angeles, Calif.

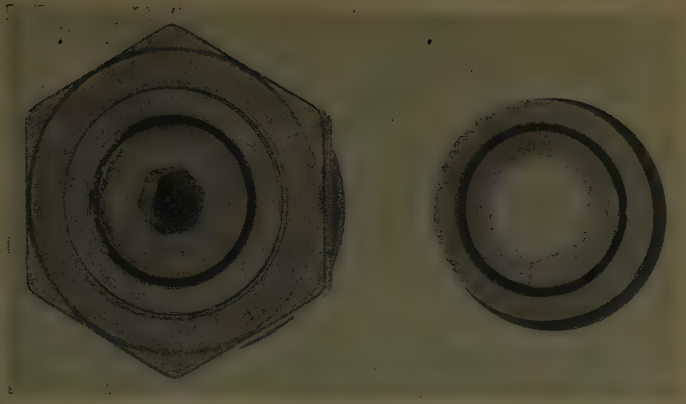


Figure 3. Counterpoise gaps which are used to prevent corrosion on the Boulder lines are a reliable means of recording lightning data. They measure the comparative intensity of lightning strokes as well as their frequency

indicators are installed also on a small number of transmission-line towers.

During the month of May the transmission lines are practically free of lightning, so this month has been used generally to examine and recondition the installed lightning recording equipment. A lightning year, as designated in this article, begins about the middle of May and ends about the end of April. Exception to this was the year 1936, which includes some data from the 1934–35 season when the first circuits were under construction.

Since the counterpoise gaps are installed throughout the line, they are relied upon for a large part of the data. Prior to 1943–1944 these gaps were surveyed once a year, but since that time the gaps have been inspected several times a year by the line patrolmen. After the first few years of experience a coding system was developed to facilitate inspection and reporting. During 1947, 1948, and 1949 the

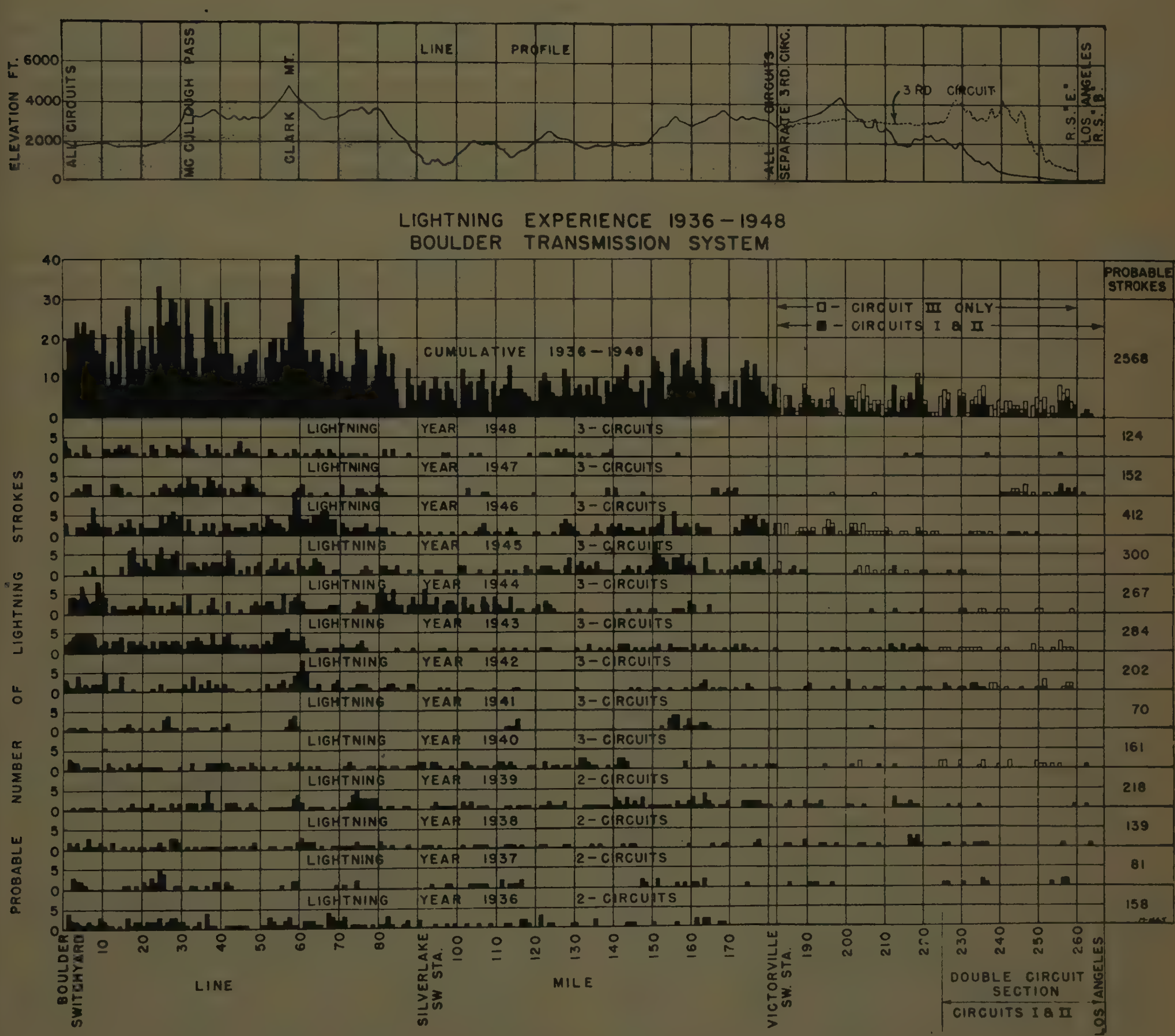


Figure 4. Chart showing the probable number of lightning strokes per line mile per year and the cumulated number of strokes for the 13-year period

average number of flashed gaps per year was 1,250, and it was found that at least 15 per cent of these counterpoise gaps had been flashed over more than once during a period of one year.

The estimation of the number of lightning strokes from the counterpoise gap data requires some judgment, as a lightning stroke may be direct, involving several towers, or it may be indirect, causing a small burn on only one gap. This is the reason for the designation "probable lightning strokes" used in this article.

LIGHTNING PERFORMANCE DATA

Figure 4 presents a chart showing the probable number of lightning strokes per line mile per year and the cumulated number of strokes for the 13-year period. The line profile is also shown on this chart, and the correlation

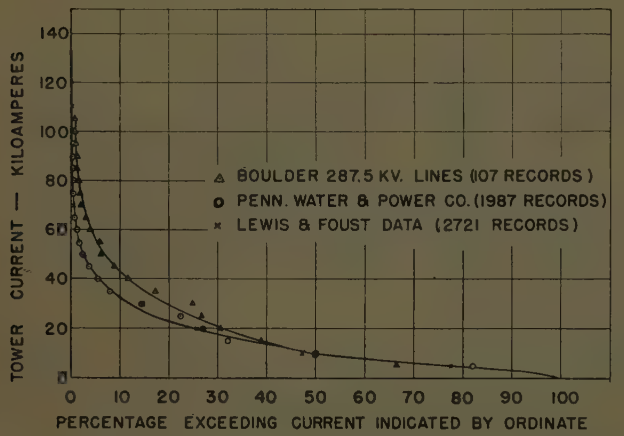


Figure 5. Distribution of tower lightning currents measured by magnetic links

between high elevation and high number of strokes is evident from the data, exemplified particularly by conditions in the vicinity of Clark Mountain, which is the highest point of the line.

From Hoover switchyard to Victorville the three 287,500-volt circuits have a normal separation of 265 feet. From a lightning standpoint these circuits are treated as one line. From Victorville to Los Angeles, Circuit III traverses a different route, as shown in Figure 2; therefore this section is treated as another line, and the data of Figure 4 are presented on this basis. The miles of double-circuit construction for Circuits I and II are indicated on the line profile and on the chart.

The magnetic links, surge recorders, lightning rods, and fuse wires are examined once a year. The low tower-footing resistance and the high insulation level on the Boulder lines preclude flashovers on low or moderate values of tower surge currents.

In the use of the magnetic links, accuracy on the low values of current is sacrificed in favor of high tower currents, and the two links are placed 6 and 18 inches from the center of gravity of the tower leg instead of the usual 3 and 9 inches.[3] On lightning-rod installations distances for the links of 9 and 27 inches are used.

Since the magnetic-link installations cover only a small portion of the transmission line, the results obtained from them are limited. The curve of Figure 5 presents the data available. The currents plotted are from magnetic-link measurements on all four legs of 107 towers, and are grouped in steps of 5,000 amperes each. Figure 5 presents also the results from 1,987 measurements reported by the Pennsylvania Water and Power Company, and 2,721 measurements reported by W. W. Lewis and C. M. Foust in the AIEE *Transactions*.[4,5] The small discrepancy between the Boulder line curves and the other data may result from the large difference in number of records, or it may result from the different methods of using the magnetic links on the different lines.

In the 13 years of operation of the Hoover lines, there have been only two circuit tripouts attributed to lightning, and one tripout which probably resulted from lightning but for which the evidence is not definite. The chart of Figure 4 shows that the probable number of strokes to the lines during this period was 2,568, which represents an average of 198 strokes per year. On the basis of three tripouts resulting from lighting, this is only 0.072 outage per 100 miles of line per year, and 0.032 outage per 100 miles of circuit per year, which is an excellent record and demonstrates the effectiveness of the overhead shielding and counterpoise lightning protective features which are incorporated in these lines.

SUMMARY AND CONCLUSIONS

1. The counterpoise gap serves as a valuable and inexpensive means of indicating lightning activity and comparative intensity on transmission lines equipped with counterpoise.

2. The excellent lightning performance of the Boulder 287.5-kv transmission lines, over the first 13 years of operation, of 0.072 outage per 100 miles of line per year demonstrates the effectiveness of overhead ground wires and continuous counterpoise system.

3. Data from a limited number of magnetic-link installations indicate:

(*a*). Oscillatory surge currents predominate over unidirectional currents.

(*b*). Cloud polarity is predominantly negative.

(*c*). The percentage distribution with respect to magnitude of tower currents compares favorably with published data from other sources.

(*d*). Tower surge currents are generally not divided equally in the four tower legs.

(*e*). Some tower surge currents in the order of 100,000 amperes have been recorded on the Boulder line, and these have not caused line flashovers.

REFERENCES

1. Engineering Features of the Boulder Dam–Los Angeles Lines, **E. F. Scattergood.** *Electrical Engineering* (AIEE *Transactions*), volume 54, May 1935, pages 494–512.

2. Lightning Performance of 220-Kv Transmission Lines—II, **AIEE Committee Report.** *Electrical Engineering* (AIEE *Transactions*), volume 65, February 1946, pages 70–6.

3. Direct Measurement of Surge Currents, **C. M. Foust, J. T. Henderson.** *Electrical Engineering* (AIEE *Transactions*), volume 54, April 1935, pages 373–8.

4. An Eight-Year Investigation of Lightning Currents and Preventive Lightning Protection on a Transmission System, **E. Hanson, S. K. Waldorf.** *Electrical Engineering* (AIEE *Transactions*), volume 63, May 1944, pages 251–8.

5. Lightning Investigation on Transmission Lines—VIII, **W. W. Lewis, C. M. Foust.** *Electrical Engineering* (AIEE *Transactions*), volume 64, March 1945, pages 107–15.

Electric System Expansion in the Pacific Southwest

H. A. LOTT
MEMBER AIEE

THE PACIFIC SOUTHWEST area includes all of the interconnected electric systems in Arizona, California, and southern Nevada. The area, 380,000 square miles, is 12.5 per cent of the land area, contains 7.7 per cent of the estimated population, and uses 10 per cent of the energy generated by central stations in the United States. The area is generally arid and because of uninhabited mountain and desert areas, the electrical service areas of the three states cover less than one-fifth of the land area.

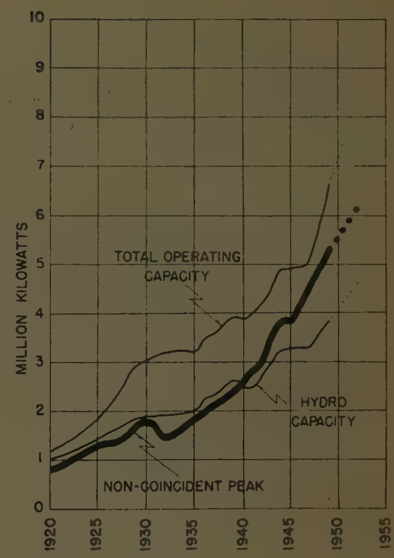
The first electrical service was furnished from small fuel plants and from hydro plants which utilized the power drop incident to irrigation and hydraulic mining. There was no coal, and during the early years fuel oil and gas had not been discovered in quantity. The increasing demand for power and water led to the search for and discovery of excellent mountain reservoir sites and power drops, and ultimately to pioneering in the development and construction of long (over 250 miles) high-voltage transmission lines and to hydro generation as the principal source of power. In 1923, the standard adopted for high-voltage transmission was 220,000 volts.

Early in the development period, it was apparent that steam generation was required to augment hydro in dry years and to act as standby and reserve. The early discovery of petroleum provided an abundant fuel supply. The utilization of hydro as the principal source of generation continued until 1940, by which time the remaining undeveloped hydro sites became progressively less desirable from the economic viewpoint and steam generation began to take over the dual role of base-load generation and reserve for hydro.

The population of the Pacific Southwest area is now estimated to be $11^1/_2$ million. The per capita use of electric energy was 2,400 kilowatt-hours per person per year in 1948. During the past 30 years the average population increase was 3.9 per cent and the average increase in per capita use was 3.1 per cent, each compounded annually. Together these values represent the average long-term increase in the use of electricity of 7.0 per cent, compounded annually, roughly the equivalent of doubling each ten years. In 1949, 29.2 billion kilowatt-hours were generated.

The total generating capacity and peak demands are illustrated on the graph of Figure 1. The annual noncoincident peak was 5.3 million kw in 1949. The dotted line extensions of the capacity graphs represent generating capacity planned and on order, while peak demand is estimated to increase at the rate of five per cent per year. The peak demand crossed the total hydro-capacity line in 1940 emphasizing the trend toward the increasing reliance on steam generation. Following the war curtailment, construction was started again and 1.7 million kw of new generating capacity were added from 1947 to 1949 inclusive, and an additional 1.7 million kw will be installed from 1950 to 1952 inclusive, a 70-per cent increase in six years. Sixty-two per cent of the 3.4 million kw of new generating capacity will be in fuel plants; fuel plants which constituted 37 per cent of the total generating capacity in 1928 will have increased to 45 per cent of the total $8^1/_8$ million kw by 1952. Seventy-eight per cent of the new generating capacity will be added by local agencies and 22 per cent will be added by the United States. The new capacity has established a satisfactory margin between demand and capacity, and the margin is expected to approach a value of 15 per cent by 1952, even if 1952 is dry.

Figure 1. Total generating capacity and peak demands in the Pacific Southwest area. The dotted line extensions of the capacity graphs represent generating capacity planned and on order, while peak demand is estimated to increase at the rate of five per cent per year



Interconnections have been used between local utilities since electrical service was started. A frequency barrier, which was eliminated in 1948, required the use of 50/60-cycle frequency changers or isolated generators which could operate at either frequency, for some interconnections. The first high-capacity interconnection between northern and southern California systems was made in 1937. The Nevada and Arizona systems came into the interconnection picture in 1936 and 1942, respectively, when the Hoover and Parker power plants were constructed on the Colorado River.

In general, the interconnections between systems were designed to consist of from one to three relatively high-capacity ties. There is no area-wide contract arrangement for parallel operation, but there are interchange agreements between practically all adjacent utilities. The simple high-capacity interconnections may be and are operated with manual control of tie-line load with the larger central utility regulating time and frequency and the systems on the periphery regulating tie-line loads.

Digest of paper **50-139**, "Expansion of the Electric Systems in the Pacific Southwest," recommended by the AIEE Committee on System Engineering and approved by the AIEE Technical Program Committee for presentation at the AIEE Summer and Pacific General Meeting, Pasadena, Calif., June 12–16, 1950. Scheduled for publication in AIEE *Transactions*, volume 69, 1950.

H. A. Lott is with the Southern California Edison Company, Los Angeles, Calif.

Electrical Essays

Polarization or Charge in a Dielectric?

A certain kind of wax is melted in an insulating tray, on the bottom of which is placed a flat electrode. Another flat electrode is laid on the upper surface of the melt, and a potential difference is applied to the electrodes. The wax is then allowed to cool until it is solid, the potential difference being maintained all the while.

On removing the solid wax it is found to be permanently electrified. A steady electric field is found to exist around it, as determined by the force observed on a charged small body or probe placed in the empty space around the wax.

It may be that when molten the wax had a slight electrical conductivity, and not necessarily a uniform one, so that opposite charges were conducted towards the two electrodes respectively. On cooling, the conductivity became zero, and the now perfectly insulating wax had frozen into it true or real volume charge densities, and it is these real charges which produce the external field.

Or it may be that the wax had a polarizability when molten, perhaps due to molecular dipoles which were free to rotate and line up in the field in the melt. On cooling, these dipoles lost their freedom to turn, and thus were frozen into their lined-up condition, leaving the wax permanently polarized, acting like the electrical equivalent of a permanent magnet. The charge then would be apparent and not real, and given by

$$\rho' = -\text{div } \mathbf{P}$$

where **P** is the polarization density, or the sum of the molecular dipole moments per unit volume, as Bill explained in a previous essay (*EE, May '50, p 456*).

How may one determine which of these views is correct?

J. SLEPIAN (F '27)
(Westinghouse Research Laboratories, East Pittsburgh, Pa.)

A Paradox?

Consider the case of a 100-kva 3-phase core-type 12-kv/-208–120-volt delta-Y platform-mounted transformer supplying a semirural area, and protected by fuses on the high- and low-voltage sides as in Figure 1.

Following confused complaints received from consumers, a trouble-shooter—whose previous experience, unfortunately for him, has been limited to single-phase systems—goes to the transformer to set things right. He fails to note that one high-voltage fuse has blown, and proceeds to check the outgoing low-voltage fuse with a lamp. He finds, by checking to neutral, that phase *A* seems all right, that phase *B* appears to be out, and that phase *C* is alive but that the voltage there seems low. Leaving his lamp connected between *C* and neutral, he removes the fuse from phase *B*, intending to replace it. The lamp immediately goes out, but relights as soon as the supposedly faulty phase-*B* fuse is replaced. Thinking that leads may be crossed, he removes phase-*C* fuse only to find that the lamp still goes out. Should the spirit of inquiry outweigh his sense of duty, he may connect his lamp between an active and neutral on the "live" side of the fuses. Those who have done this know the *dreadful* things that happen when the low-voltage fuses are removed and replaced!

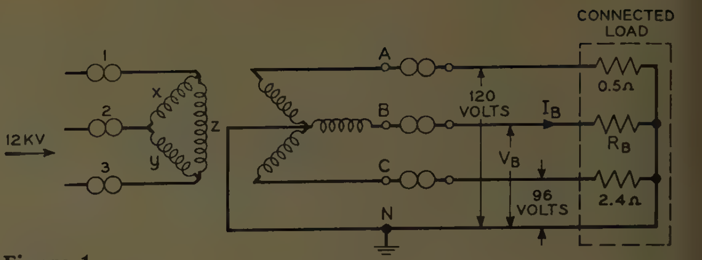


Figure 1

While the unhappy man is working feverishly, unfettered and unaided by theory or practice, let us examine the problem. Before he arrived, the connected load was purely resistive as shown in Figure 1. Assuming an ideal transformer:

1. Which high-voltage fuse was blown?
2. What are the values of V_B, I_B, and R_B?

A. G. BENEDICT
(Brisbane Water County Council, Gosford, New South Wales, Australia)

Answer to Previous Essay

Force on a Cut Iron Cylinder. The following is the author's answer to his previously published essay (*EE, Jul '50, p 635*).

J. H. Gittings and A. E. Stitely have made a direct test in East Pittsburgh of the configuration shown in Figure 1*C*, of the essay and reported the results to me. They made cuts in a 5/16-inch-diameter iron rod, and mounted the parts in a slightly larger diameter brass hollow cylinder, so that the iron parts, though compelled to stay on the same vertical axis, could slide up and down vertically freely. The middle two parts rested on each other and on the lower part of the iron cylinder, the upper part set so that the horizontal cut under it made a gap of 0.015 inch.

On turning on a vertical magnetic field of 1,000 gauss or so, the top middle part jumped up, closing the horizontal air gap, and opening up the diagonal 45-degree gap.

Bill tells me that this result confirms his formula for the force on the apparent charge (*EE, June '50, pp 551–2*). Charlie, however, claims that this experiment is a great victory for his different formula based on the action of magnetic dipoles in a nonuniform magnetic field. Jack said that this experiment shows very clearly the correctness of his still different formula based on the action of magnetic fields on amperian currents.

If the reader will look up my discussion of Maxwell's stress integral (*EE, Nov '49, pp 985–7*), he will discover how to make up a few formulas of his own, which will be confirmed by the experiment of Gittings and Stitely.

J. SLEPIAN (F '27)
(Westinghouse Research Laboratories, East Pittsburgh, Pa.)

Dynamoelectric Amplifiers

R. M. SAUNDERS
MEMBER AIEE

Much has been written recently concerning the theory and the operating characteristics of individual dynamoelectric amplifiers. This article serves to collect in one place the basic theoretical principles of all types of dynamoelectric amplifiers, describes some of the salient features of all these devices, and suggests means of predicting their performance.

DYNAMOELECTRIC amplifiers enable the electrical engineer to apply many useful characteristics of electronic amplifiers to rotating machinery on an economic basis. While amplifiers involving vacuum tubes, thyratrons, and ignitrons are quite satisfactory from a performance point of view, they are generally prohibitive economically in the sizes desired for application to power machinery. It is the purpose of this article to describe the principles underlying the operation of the various dynamoelectric amplifiers, to describe briefly their characteristics, and to suggest methods of analysis for circuits involving these devices.

The American Standards Association definition of an amplifier is "...a device for increasing the power associated with a phenomenon without appreciably altering its quality, through control by the amplifier input of a larger amount of power supplied by a local source to the amplifier output." D-c generators fulfill these requirements as do some other rotating machines; such rotating machines that act as amplifiers in the sense of this definition are customarily regarded as dynamoelectric amplifiers. At present there are five dynamoelectric amplifiers available: the standard separately excited d-c generator, the Amplidyne, the Rototrol, the Regulex Exciter, and the VSA Regulator. The first of these is not a very practical amplifier but is of interest as an introduction to the consideration of the subject of the dynamoelectric amplifier. The other four constitute the practical machines as used today.

THE D-C MACHINE AS A DYNAMOELECTRIC AMPLIFIER

FIGURE 1 shows a standard d-c machine connected for service as an amplifier. The field circuit is arranged to be excited from a source of alternating current, and the armature is driven in the usual fashion by a suitable constant-speed motor. If an alternating voltage E_c is impressed upon the control field, a generated voltage E_G will result in accordance with the construction of Figure 2 where BA is the standard open-circuit saturation curve. The generated voltage E_G will be an exact image of the impressed voltage as long as only the straight-line portion of the saturation curve is employed. If the amplitude of the control field voltage is increased further, the output voltage will be distorted. The load voltage will be the generated voltage minus the armature copper resistance drop, the brush drop, the armature inductance drop, and the voltage drop due to the demagnetizing component of armature reaction which may be replaced by a simulated resistance drop.

Some reflection would lead one to the conclusion that this situation has a close analogy to the vacuum-tube amplifier. However, further consideration would reveal very significant differences. In the case of the dynamoelectric amplifier there is grid current (control-field current) flowing whereas in the class-*A* vacuum-tube amplifier there is none. In the d-c machine the plate supply is mechanical energy, and no d-c component of current flows in the load circuit as in the case of the vacuum-tube amplifier, thus eliminating the problem of the blocking capacitor. In so far as analysis is concerned, the usual vacuum-tube amplifier problem is with the a-c components only, and in the case of the dynamoelectric amplifier the same general theory of vacuum-tube amplifiers will hold provided one bears in mind that the grid circuit will now draw current.

To the usual characteristics of interest in electronic amplifiers, that is, the over-all transconductance, the frequency response, the transient response to shock voltages, the voltage gain, and the zones of stability, must be added the power amplification. This quantity is rather meaningless in class-*A* vacuum-tube amplifiers where the grid

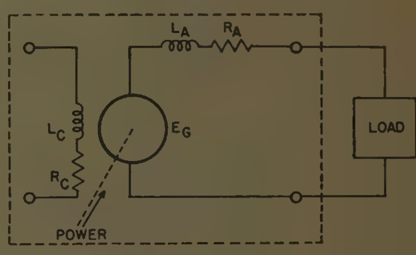


Figure 1. D-c machine connected for dynamoelectric amplifier service

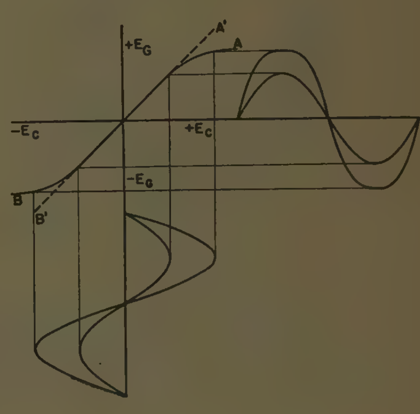


Figure 2. Relationship between control-field voltage and generated voltage. Distortion is introduced when control voltage swings past the straight-line portion of the curve

R. M. Saunders is with the University of California, Berkeley, Calif.

current is zero but is of extreme importance in the case of the dynamoelectric amplifier.

As compared with the more recently developed dynamoelectric amplifiers, d-c machines are characterized by low power amplification and large time constants. For these reasons, d-c machines have been used less frequently in this service in recent years.

THE AMPLIDYNE

THE second dynamoelectric amplifier to be considered here is the Amplidyne. The term Amplidyne is a coined word which indicates the application of the metadyne to dynamoelectric amplifier service. The Amplidyne belongs to the class of machines known as armature-reaction generators, the first of which was the Rosenberg generator originally developed in 1905 for train-lighting service. The theory of the Rosenberg generator is well described by Langsdorf.[1] The metadyne, the direct antecedent of the Amplidyne, was developed in France around 1930 and used primarily as a converter of constant-potential energy to constant-current energy.

The Amplidyne was announced, its theory described, and possible applications pointed out in 1940 by the General Electric Company in three papers.[2–4] Graybeal,[5] Crever,[6] and more recently, Bower[10] further amplified Fisher's[3] original paper on the basic theory. An elementary explanation of its principles follows. In Figure 3A, the cross section of a customary d-c machine, if there is a current flowing in a winding placed upon the field poles, a magnetomotive force F_c will be set up in the plane of the poles in a downward direction for the current direction shown. This field is called the control field. Now, the magnetomotive force F_c will cause a flux to be established in the air gap, linking the armature conductors. With a counterclockwise rotation, electromotive forces will be generated under the upper poles out of the page and into the page for the conductors over the lower poles as shown in Figure 3A. So far there is no difference between this machine and the usual d-c generator. In Figure 3B the brushes have been short-circuited and current will flow from brush to brush and in the armature in the same directions as the electromotive forces of Figure 3A. Immediately upon establishing a current in the armature conductors, there will be an armature magnetomotive force also established whose direction is governed by the familiar right-hand rule. Letting F_q represent this armature-reaction magnetomotive force, there will now be two magnetomotive forces present in the machine—these magnetomotive forces being shown as space vectors to the right of Figure 3B. In Figure 3C an additional set of brushes has been placed in the direct axis and a low-reluctance magnetic circuit provided so that the armature-reaction

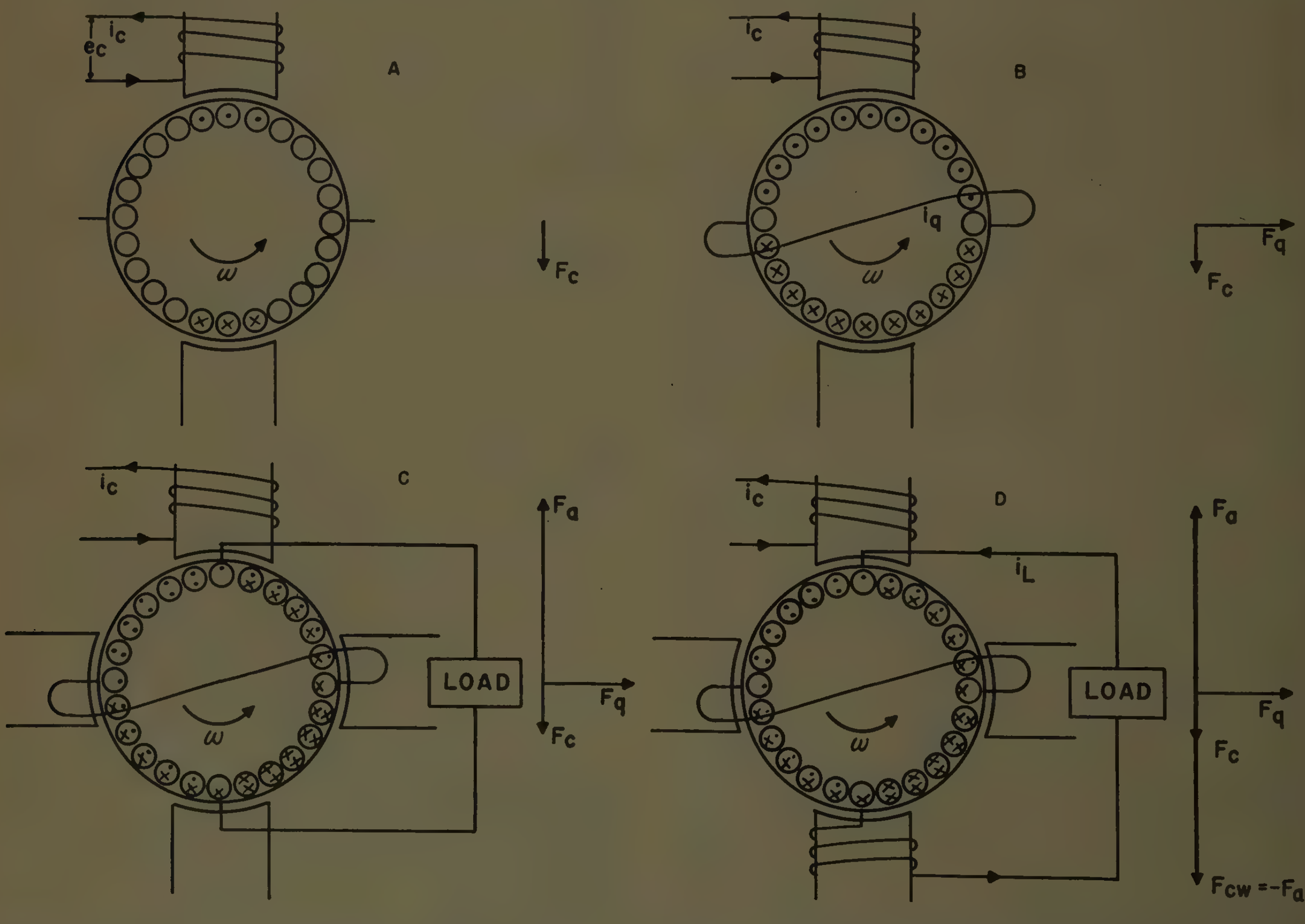


Figure 3. Evolution of the Amplidyne from the d-c machine. (A) Voltage and magnetomotive force for no load; (B) currents and magnetomotive forces for short circuit; (C) addition of brushes and quadrature poles which result in metadyne operation; (D) currents and magnetomotive forces for Amplidyne operation

magnetomotive force can establish a flux of considerable magnitude in the quadrature axis. Until this modification has been made, this has been a customary d-c machine operating under short-circuit conditions. The addition of the direct-axis brushes and the quadrature poles makes this machine different from the usual, especially the addition of the poles, since in the usual machine it is desired to suppress, rather than encourage, the armature-reaction flux. Because the armature-reaction flux links the same conductors of the armature as the control-field flux, it, too, will generate electromotive forces whose directions are shown in the shaft half of the conductors of Figure 3*C*. (The individual conductors of Figure 3*A* have each been divided into two parts to differentiate between the action of the two magnetomotive forces and fluxes, the air-gap halves of these conductors having the directions of the short-circuit current flow due to the control field.) When the direct-axis brushes are connected to a load, current flows in the armature conductors in the same directions as the electromotive forces which cause this current flow,

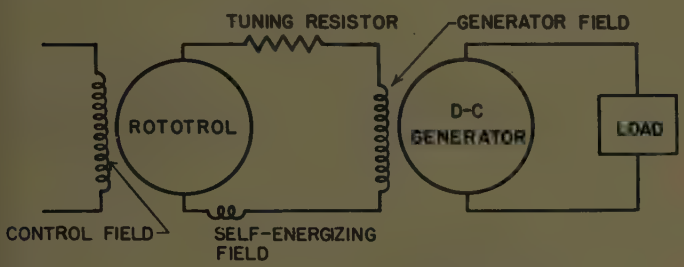
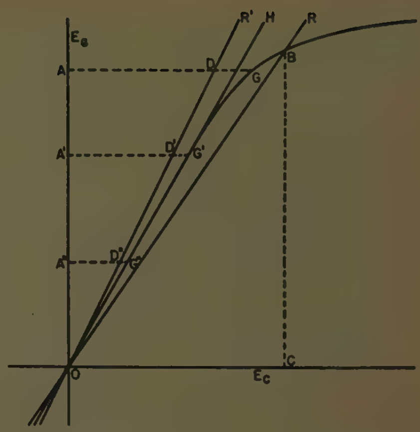


Figure 4. Connection diagram for a Rototrol driving a quick-response generator. Operation depends on adjustment of the load-circuit resistance to the critical resistance of the machine

that is, in the directions shown in the shaft halves of the armature conductors of Figure 3*C*.

In the same fashion as before, the armature current will have a magnetomotive force F_a associated with it whose direction will be such as to oppose F_c. If the machine were left in this condition, F_a would cause a flux to be established which would generate an electromotive force in the quadrature axis and cause a new current to flow in the short-circuit axis. The net result would be that F_c would lose control and the generator would operate as a constant-current generator (a metadyne). To display amplifier characteristics F_a must be neutralized by a compensating winding on the direct-axis poles, as in Figure 3*D*. The compensating winding is placed in series with the load current so that F_{cw} is proportional to the load current, as is F_a, and is adjusted so that it is very close to being equal to the load-current armature-reaction magnetomotive force F_a. Thus the only magnetomotive force remaining in the direct axis is F_c, and it assumes complete control over the output voltage, dictating what it shall be. Crever[6] points out that F_c is relatively small compared to that in the usual d-c machine, a factor which materially increases its response characteristics. The inductance of a linear circuit is directly proportional to the magnetomotive force so that the inductance of the control field is greatly reduced with the small magnetomotive force requirement. Further,

Figure 5. Saturation curve and circuit-resistance lines illustrating Rototrol operation. Contribution of the self-energizing field is to the left of OR; that of the control (pilot) field lies between OR′ and OG′GB



the resistance can be increased so that the time constant is still further reduced.

It is generally conceded that the Amplidyne is a 2-stage amplifier, one stage from control field to quadrature axis and one from quadrature back to the direct axis. If the power is amplified 100 times from the control field to the quadrature axis, it will be multiplied another hundredfold from the quadrature axis to the load axis again. Hence, the over-all power amplification is $(100)^2$ or 10,000. Another manner of examining this property is to consider the magnetomotive forces. Since the magnetomotive force establishing an electromotive force is linked by certain constants to that electromotive force, it follows that the square of the magnetomotive force represents power in the same fashion as the square of the voltage drop across a resistance. Hence, if the magnetomotive force is increased by a factor of ten from the control axis to the quadrature axis, $F_q = 10F_c$ and $F_a = 10F_q = 100F_c$. Squaring and letting F_c be proportional to the power input, the power output is then $(10)^4 F_c^2$, or the power amplification is 10,000.

THE ROTOTROL

THE term "Rototrol" is also a coined word indicating the use of a rotating machine as a control device. Developed for the requirements of elevator service by the Westinghouse Electric Corporation in 1932, it was found to serve as a dynamoelectric amplifier as well.

While there are a large number of papers available describing the applications of the Rototrol, there are very few describing the principles of operation[7,8]—thus reflecting, to a certain extent, the simplicity of these principles. Basically, the simple Rototrol unit consists of a standard d-c machine with two fields called the pilot (control) and self-energizing fields. The method of connecting the self-energizing field, the tuning resistor, the load (in this case the generator field), and the armature is as shown on the left half of Figure 4; the operation of this unit depends upon a close adjustment of the load-circuit resistance to approximate the critical resistance of the circuit. Referring to Figure 5, unless the field-resistance line *OR* has a slope less than the slope of the air-gap line *OH*, the generator will not build up at all. For a given field-circuit resistance represented by *OR*, the final open-circuit voltage will be *BC*. If the slope of *OR* is increased by increasing the circuit resistance so that it assumes the position of *OH*, the point *B* may lie any place along the

portion of that line which coincides with the open-circuit saturation curve OB. In the normal generator this coincidence of the open-circuit saturation-curve air-gap line with the field-resistance line represents an unstable condition, for, with a given field resistance, the terminal voltage may stabilize at any value along the straight-line portion of the open-circuit saturation curve. If the slope of the field-resistance line is increased to OR', the generator voltage cannot be built up by the series or self-energizing field alone. However, it can be built up by the addition of magnetomotive force contributed by another field. Suppose OR' has a slope slightly greater than that of OH; then a very small magnetomotive force DG, $D'G'$, or $D''G''$ will give rise to the voltage OA, OA', or OA'' respectively. As long as the straight-line portion of the saturation curve is employed, the relationship between this small incremental control-field magnetomotive force and the resultant voltage will be linear. The slope of the line OR' is determined by the resistances of the self-energizing field, the load resistance, the armature resistance, the brush resistance, and a small adjustable resistor called a tuning resistor. The small incremental magnetomotive force F_c is contributed by the control (pilot) field. Since this magnetomotive force is relatively small, the inductance of the control field can be made very small, compared to the same size d-c machine; hence the time constant is much lower and the frequency response increased over that of the same machine operating as the usual d-c generator. This situation is analogous to the case of the Amplidyne. In both instances a small magnetomotive force gives rise to large changes in voltage and power output. In the case of the Rototrol the power amplification can be chosen at will by the simple expedient of varying the tuning resistor, thus adjusting the slope of the resistance line. As OR' approaches OH, the power amplification factor increases and will become infinite when OR' lies along OH. In many applications this very procedure is employed, so that on the surface it would appear as if the amplifier were operating under unstable conditions; however, negative feedback is always employed in these cases so that stable operation results.

Because of the necessity that the load resistance remain constant (so as to retain the constant slope of the resistance line), the usual application of the Rototrol is as an exciter for the quick-response generator as shown in Figure 4. The addition of another generator slows down the over-all response but increases the over-all power amplification. The addition of the generator also eliminates the problem imposed by a variable resistance load.

Frequently a pattern field is employed. This field serves as a constant bias causing operation at OA' (Figure 5) when no signal is impressed. The control field then opposes the pattern field, and the output voltage is reduced

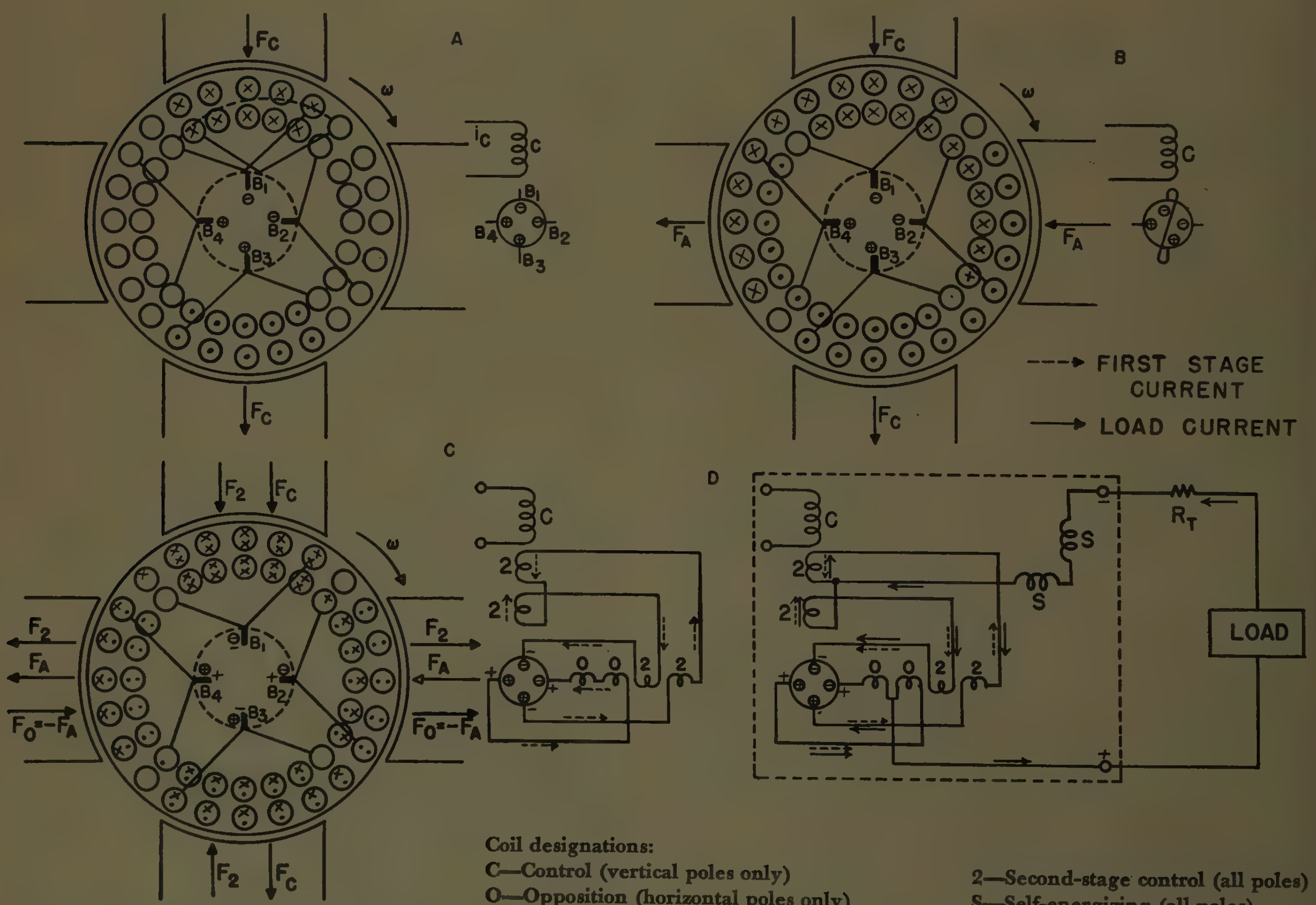


Figure 6. Current, magnetomotive force, electromotive force, and coil arrangement in the 2-stage Rototrol. (A) Relations established by the first-stage control field current; (B) effects of closing the armature circuit; (C) 2-stage Rototrol at no load; (D) the complete circuit of a simplified 2-stage Rototrol under load conditions

when the signal is received. If the speed of the Rototrol is decreased for any reason, the amplification is seriously reduced since the distance from the resistance line to the saturation curve increases at any given point. To offset this, a voltage proportional to speed is sometimes injected together with the pattern field voltage. The two act to keep the magnetomotive force required for a given amplification constant for small changes in speed.

Thus far this discussion has been limited to the single-stage Rototrol. Rototrols with two stages have been built where very large power amplifications are required, and Liwschitz[9] has postulated the multistage Rototrol. The basic principle of the 2-stage Rototrol is shown by Kimball[11] to lie in the fact that a 4-pole magnetic structure can result in three separate machines. In general a p-pole machine will result in (p-1) separate machines or a (p-1)-stage amplifier providing a lap winding without equalizers is employed. Figure 6A shows such a winding for a 2-stage Rototrol and the electromotive forces at the commutator end of the conductors that would be developed for a control-field magnetomotive force in the downward direction in the vertical poles. The control field is placed

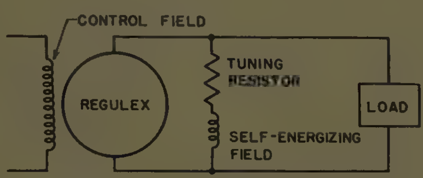


Figure 7. Connection diagram for the Regulex Exciter and the VSA regulator

on one pair of poles only; hence there is no electromotive force due to control-field current developed under the horizontal poles. For clarity only a few conductors are shown connected to the commutator. Suppose, now, that the brushes B_1 and B_3 are short-circuited as in Figure 6B; current will flow in the armature conductors and will be in the directions indicated. The armature magnetomotive force F_A will be established as a result of this current flow. Note that the conductors lying under the horizontal poles contribute no magnetomotive force to the armature magnetomotive force, for the current flow is in the opposite direction in adjacent conductors. If F_A were unopposed, an electromotive force would be generated such as to produce a magnetomotive force in opposition to F_c when the other two brushes were connected to the load. One possible solution is to place opposition coils on the horizontal poles that will balance out F_A. These coils are shown in Figure 6C connected between B_2 and B_4 which are the same potential as B_1 and B_3 for the first stage. Also in Figure 6C is shown the manner of connecting the second-stage control coils, the magnetomotive forces for these coils and the opposition coils, and the electromotive forces developed by the second-stage magnetomotive forces. As in the explanation of the Amplidyne, the conductors are divided in two parts to show the separate electromotive forces and currents. The upper halves show electromotive forces and currents for the control magnetomotive force while the lower halves show the electromotive forces and currents for the second stage. The second-stage control coils are placed on all four poles and are arranged to

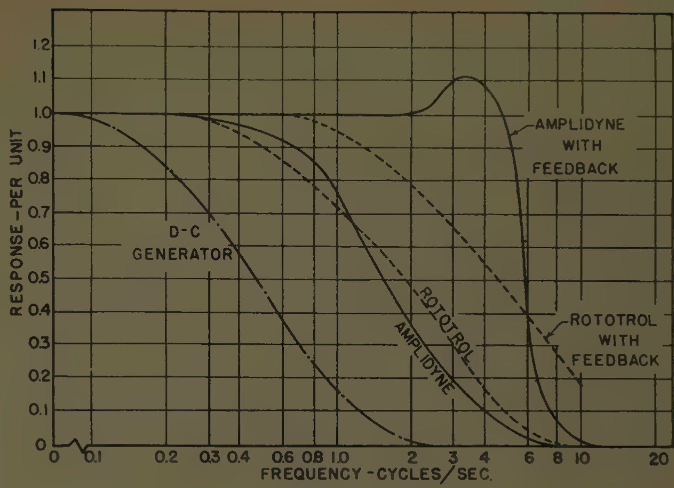


Figure 8. Typical frequency-response curves for various dynamoelectric amplifiers. The two curves at the right are for the same machines as at the left but with negative feedback

produce electromotive forces at the brushes in the same fashion as for the customary 4-pole d-c machine. The connection of the output circuit to the opposition and second-stage control coils is shown in Figure 6D, for in normal d-c machine operation brushes B_1 and B_3 are at the same potential and are connected together as are B_2 and B_4. These connections are made at the center of the opposition and second-stage control coils. Usually only the second stage is tuned in the same sense as the single-stage Rototrol so that the self-energizing field and load are connected into the circuit as shown in Figure 6D, the self-energizing field coils being placed on all poles and producing magnetomotive forces in the same directions as the second-stage control coils. Thus, a small amount of power input to the control field will give rise to a large output power to the load, the extra power being supplied by the drive motor. For discussions pertaining to the problem of commutation the reader is referred to papers by M. M. Liwschitz,[9] A. W. Kimball,[11] B. Litman,[13] and J. T. Carleton.[14]

THE REGULEX EXCITER AND VSA REGULATOR

The Regulex Exciter and VSA Regulator are products of the Allis-Chalmers Company and the Reliance Electric and Engineering Company, respectively, and are similar to the single-stage Rototrol except that the self-energizing field is connected in a shunt arrangement as in Figure 7. The performance is very similar to the Rototrol.

CHARACTERISTICS

All the foregoing dynamoelectric amplifiers have one characteristic in common: the plot of the control-field voltage or current versus the generated voltage in the next stage can be represented by a curve of the same type as that shown in Figure 2. From a family of such curves one may make computations pertaining to the d-c characteristics of the dynamoelectric amplifier. In many cases, the voltage applied to the control field rises slowly enough so that the transient behavior need not be considered. When the unit is shock-excited or is subjected

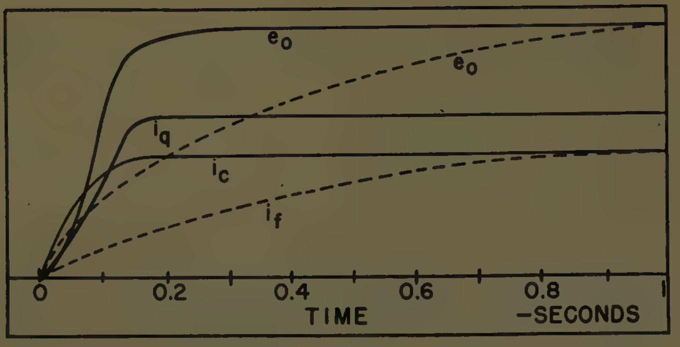


Figure 9. Shock excitation characteristics of an Amplidyne and an equally rated d-c machine. The output voltage and field current of the d-c machine are shown as dotted curves and the output voltage, quadrature axis current, and control-field current are shown as solid lines

to alternating current in the neighborhood of one cycle per second, the various units must be considered either on a transient basis or as an a-c network.

When considered from an a-c point of view, the frequency-response curve, the phase-angle shift, and the zones of stability are of importance. The left three curves of Figure 8 are typical response curves for units rated approximately 500 watts. The reason the d-c generator is of little importance as a dynamoelectric amplifier is apparent from the curves; the low value of frequency cut-off precludes its application to most situations requiring amplifiers. The frequency response of other equally rated dynamoelectric amplifiers appears to be essentially the same. Since the armature and control-field circuits are essentially inductive in nature, the magnitude of the time constant will be the controlling factor in the limit of the flat-response part of the curve. In most cases, the inductance of the armature circuit is negligible with respect to the field circuit, and a very good approximation to the frequency response can be obtained by considering only the impedance of the control circuit. The inductance of the control field can be kept low in the dynamoelectric amplifier since only a very small magnetomotive force is established by the control field. Further, the control field can be driven by a high-impedance generator (a pair of *6L6*'s in push-pull is common) so that the control-field resistance can be made relatively large. These factors tend to decrease the time constant of the control field, and thereby increase the frequency response over that of the d-c machine.

When considering the dynamoelectric amplifier from a transient point of view, one is concerned frequently with its response to shock excitation; the response of a 3/4-kw Amplidyne and a 3/4-kw d-c machine to this type of driving voltage is shown in Figure 9. This characteristic is important in the application of the dynamoelectric amplifier to open types of control systems. Here again the long time constant of the d-c machine is apparent.

For a more complete analysis of the machine under transient conditions J. L. Bower's work[10] is of considerable importance, and for a consideration from the a-c point of view, a paper[12] by R. M. Saunders may be of interest.

FEEDBACK

Most dynamoelectric amplifiers employ negative-feedback networks of various kinds. If the amplifier is driven by a vacuum-tube amplifier, the feedback may be introduced in some earlier stage; however, this practice leads to various difficulties because of the phase shifts throughout the system. Negative feedback over the two stages of the dynamoelectric amplifier is a very common and successful practice and results in better over-all frequency characteristics at the expense of amplification. The two curves at the right of Figure 8 show this effect. In comparing the Rototrol and the Amplidyne response curves, it must be remembered that the former is a single-stage amplifier and the latter a 2-stage unit.

An interesting case of negative-feedback operation is the usual Rototrol operation. Usually the amplification without feedback is made to be infinite. In this case the general expression for over-all voltage amplification of amplifiers with feedback becomes:

$$\lim_{A_0\to\infty} (A) = \lim_{A_0\to\infty}\left(\frac{A_0}{1-\beta A_0}\right) = -\frac{1}{\beta}$$

Thus the characteristics and distortions of the amplifier contribute nothing in the output circuit. By making β small, large amplifications can result.

APPLICATIONS

The dynamoelectric amplifier is mainly applied to closed-type control circuits. A closed (as opposed to open) control circuit is one in which a signal is returned from the load to the activating circuit for the purpose of modifying the ultimate load voltage, current, motion, and so forth. Current, voltage, and power regulators are the more simple types of these controls. These systems usually involve intermediate electronic amplifiers and control circuits, the final stage being a dynamoelectric amplifier for the purpose of energizing the drive motor.

REFERENCES

1. Principles of Direct Current Machines (book), **A. S. Langsdorf.** McGraw-Hill Book Company, Inc., New York, N. Y., 3d edition. Pages 437–46.

2. Dynamoelectric Amplifier for Power Control, **E. F. W. Alexanderson, M. A. Edwards, K. K. Bowman.** AIEE *Transactions*, volume 59, 1940, pages 937–9.

3. Design Characteristics of Amplidyne Generators, **Alec Fisher.** AIEE *Transactions*, volume 59, 1940, pages 939–44.

4. Industrial Applications of the Amplidyne Generator, **D. R. Shoults, M. A. Edwards, F. E. Crever.** AIEE *Transactions*, volume 59, 1940, pages 944–9.

5. Steady-State Theory of Amplidyne Generator, **T. D. Graybeal.** AIEE *Transactions*, volume 61, 1942, pages 750–6.

6. Fundamental Principles of Amplidyne Applications, **F. E. Crever.** *Electrical Engineering* (AIEE *Transactions*), volume 62, 1943, pages 603–06.

7. Rototrol—A Versatile Electric Regulator, **W. H. Formhals.** *Westinghouse Engineer* (Pittsburgh, Pa.), volume 2, May 1942, pages 51–4.

8. Rototrol. *Westinghouse Bulletin B3649*, July 1947, pages 27–34.

9. The Multistage Rototrol, **M. M. Liwschitz.** AIEE *Transactions*, volume 66, 1947, pages 564–8.

10. Fundamentals of the Amplidyne Generator, **J. L. Bower.** AIEE *Transactions*, volume 64, 1945, pages 873–81.

11. Two-State Rototrol for Low-Energy Regulating Systems, **A. W. Kimball.** AIEE *Transactions*, volume 66, 1947, pages 1507–11.

12. Dynamoelectric Amplifier—Class *A* Operation, **R. M. Saunders.** AIEE *Transactions*, volume 68, 1949, pages 1368–73.

13. An Analysis of Rotating Amplifiers, **B. Litman.** AIEE *Transactions*, volume 68, 1949, pages 1111–17.

14. The Transient Behavior of the Two-State Rototrol Main Exciter Voltage Regulating System as Determined by Electrical Analogy, **J. T. Carleton.** AIEE *Transactions*, volume 68, 1949, pages 59–63.

Conference Papers Digested for Summer and Pacific General Meeting

These are authors' digests of most of the conference papers presented at the AIEE Summer and Pacific General Meeting, Pasadena, Calif., June 12–16, 1950. These papers are not scheduled for publication in AIEE Transactions or AIEE Proceedings, nor are they available from the Institute.

A High-Speed Multiplier for Analogue Computers; *B. N. Locanthi (California Institute of Technology, Pasadena, Calif.).*

In solving certain types of nonlinear differential equations by means of an analogue computer, it is sometimes necessary to generate a voltage proportional to the instantaneous product of the magnitude of two or more voltages which may themselves represent parts of the solution. Most of the elements of the California Institute of Technology analogue computer produce negligible parasitic phase shifts or amplitude distortions. The phase shifts of frequency components up to 1,000 cycles have been held to one degree or less in the equipment. The amplitude distortion of frequencies up to 10 kc has generally been less than one per cent.

The multiplier consists of two balanced modulators and a demodulator. One of the voltages to be multiplied is fed to a ring modulator operating at 456 kc. The output of the ring modulator along with the second voltage to be multiplied is fed to a balanced vacuum-tube modulator. The output of the second balanced modulator is then fed to the balanced-ring demodulator, which delivers the desired product.

If the input voltage to each modulator is restricted to ± 0.5 volt, the output, representing the product, may have a peak value of the order of 2.0 volts. The distortion of the product does not exceed one per cent of the maximum value of the product for any inputs within the above limits.

The frequency response for either input is uniform from direct current to 10 kc, being down 10 per cent at 70 kc. The phase shift for either input is 1.8 degrees at 1 kc, being about 180 degrees at 100 kc. The response of the multiplier to a square wave shows a delay of 5.0 microseconds followed by a rise to within 95 per cent of maximum product in an additional 5 microseconds. The d-c drift from all sources is less than 0.5 per cent of the maximum product per hour and is due primarily to the vacuum tubes in the second modulator. The drift from the first modulator and demodulator combined amounts to less than 0.2 per cent of the maximum product.

Electrical Engineering Building at Oregon State College Features Functional Design; *Ben H. Nichols (Oregon State College, Corvallis, Oreg.).*

Contracts for a new electrical engineering building at Oregon State College were signed in June 1947. Construction was sufficiently complete by October 1948 to use a few classrooms. Further occupancy was progressive as construction of the building and installation of equipment were completed. Dedicated to the late R. H. Dearborn, formerly head of the department and dean of the school of engineering, the building now houses all activities of the Electrical Engineering Department at Oregon State College.

The L-shaped structure is constructed of reinforced concrete with an exterior of brick veneer. A cable tunnel, five floor levels, and three roof levels are used for instructional purposes.

The ground floor contains the power machinery and high-voltage laboratories which extend upward for two floor levels. An overhead crane is installed for these two rooms with provision for completely closing off all natural light for the high-voltage laboratory. A new high-voltage testing transformer is scheduled for installation in July 1950. Other floor usage includes building service space, a machine shop, and laboratories for industrial electronics, control mechanisms, and calibrating instruments.

The first floor includes offices for the School of Engineering, the Electrical Engineering Department, and for several staff members. Classrooms and the space allocated to illumination studies are also on this floor. The second and third floors in addition to the classrooms and offices contain laboratories for communication for beginning courses in electronics, for electrical measurements, and for study of basic theory of electric, magnetic, and dielectric circuits. The fourth floor and three roof levels are used for investigations of radiation from different types of antenna.

Energy is received at 11,000 volts in the building transformer vault. Circuits to the laboratories from this vault operate at 2,300 volts, 230 volts, and 115 volts three phase. Motor-generator sets and a battery provide additional sources of energy. The main switchboard for experimental purposes is located in the power-machinery laboratory on the ground floor. From this main board continuously energized circuits extend to many of the other laboratories. Transfer lines which may be connected to a particular source as needed, extend from here to all other laboratories. Each laboratory has its own distribution panel where are terminated energy sources, transfer lines, and circuits to service units.

Service units are mounted in the walls of the power machinery laboratory. The laboratories with smaller equipment generally have the service units on tables, which are provided with jacks, binding posts, convenience outlets, and polarity sockets.

Automatic Data Handling Techniques Including Records and Reduction; *William D. Bell (Telecomputing Corporation, Burbank, Calif.).*

The Telecomputing Corporation offers a computing and data analysis service to industry and science, utilizing electronic digital computers. In addition, devices are manufactured for automatic and semiautomatic recording of data into digital form.

The Telereader is a manually operated projection device which can be used to read X and Y co-ordinates from photographic data. It has two light systems and will handle records from 12-inch paper oscillographic tapes to 35-millimeter transparent film. The drive system covers both forward and reverse operation and can be varied over wide speed ranges. Reading accuracy of the instrument is 0.001 inch on the record.

In typical operation an operator can read 30 points per minute, with a mimimum of fatigue and operator error even for extended periods of operation.

The Telecorder is an electronic counter which can be coupled to various mechanical or electric systems to produce a digita measure which is recorded directly into International Business Machine (IBM) cards. (The Telecorder can be used with the Telereader for automatic transcribing of data into IBM punched cards.) Operating speed of the electronic counter is 25,000 counts per second, addition or subtraction. It is possible to take numbers out of the counter into an intermediate storage for punching without interrupting the counting operation. The recording speed is limited by the attached IBM punch which will handle 100 cards per minute.

Also nearing completion is an automatic plotting device called the Teleplotter. This machine will be actuated by punched cards, thus operating from a true digital input. Plotting speed is approximately 40 points per minute, and accuracy is one-half millimeter when using millimeter graph paper. An interesting feature of the machine is the fact that plotting is accomplished by actual counting of grid lines on the graph paper. Scale factors can be easily introduced and distortion effects are minimized.

The Telecomputing devices described make significant savings in time possible in analysis of data, and make feasible many automatic recording applications. Once data are available in punched-card form, standard IBM machines can be used for mathematical analysis of the data. Recent machines, such as the IBM Electronic 604 and also the IBM Card Programmed Sequence Calculator, make possible several hundred calculations per minute in typical operations.

A Low-Voltage Ground Fault Detecting Relay; *A. B. Chafetz (International Minerals and Chemical Corporation, Chicago, Ill.).*

It is the purpose of this paper to present a means for detecting ground faults occurring on low-voltage 3-phase ungrounded delta-connected secondary mine feeder circuits.

The circuit utilized may be described in general as an electronic relay in which an amplified control impulse is transferred to an electromechanical relay. For test purposes the relay parts were mounted in a metal box five inches wide by six inches high by eight inches long. The equipment is to be rubber-mounted and placed on the frame of the portable substation underground.

The major advantages of the electronic relay are that it is inexpensive to build

and does not require a fourth wire in the distribution cable. Also, the degree of sensitivity can be determined easily by experience so that signal operation may be obtained to suit local conditions. No means are provided for reducing potential to ground at the faulted mining machine; therefore, use of the relay will be limited to the 230-volt secondary system.

Experimental work will continue on the use of the relay and the circuit is to be altered to make it "fail-safe."

Sound Ranging at the Morris Dam Torpedo Ranges; *R. N. Skeeters* (*NOTS Underwater Ordnance Department, Instrumentation Branch, Pasadena, Calif.*).

In the development and proving of underwater missiles, test runs are made to determine their trajectory. Weapons launched from air into water must keep a true course despite disturbances occurring during the water entry phase. Accurate determination of trajectory is essential to a development and testing program for such weapons.

The Morris Dam Torpedo Ranges of the Naval Ordnance Test Station make use of sound ranging for this purpose. Suitably placed hydrophones pick up sounds generated in the missile by firing a series of exploder caps or "cannon primers." It is required to locate the missile in 3-dimensional space at the times of the detonations. Each hydrophone feeds an amplifier channel and the output of all channels is recorded by an oscillograph.

The range contains an array of 24 hydrophones of Brush-type *C23*. These are suspended from two lines on either side of the range with half at a depth of four feet and the others at 79 feet. Thus, the range provides five separate cells or parallelepiped arrays, each consisting of eight hydrophones.

To locate the missile at the time of firing a certain cap, a minimum of four signals from one cell are required. The traces on the oscillograph record are read to determine three time differences using for a reference the time indicated by the first or nearest hydrophone. The corresponding distances, computed from the known velocity of sound in water, constitute the data for the sound ranging computations which determine the x, y, and z co-ordinates of the missile at the time of firing the cap.

Reduction of the data is accomplished by a computer which is a scale model of one of the cells of the sound range. The point representing the location of the missile is moved until its distances from the corners (which represent the hydrophone locations) are consistent with the data obtained from the record and registered on scales of the computer. When consistency is achieved, all indexes will "line up" and the coordinates may be read directly from the x, y, and z scales.

A proposal has been made for an electric computer to supplement, or possibly to replace, the mechanical one now in use known familiarly as the "Jungle Gym." If successful, it should reduce the time and labor of obtaining solutions.

The principle of the proposed electric computer is that of representing distance by electric resistance or conductance in a Wheatstone bridge network. Balancing the bridge will solve for one unknown. Using linear equations derived from the quadratics which are characteristic of the sound ranging problem, it is possible to obtain a solution in four successive independent operations. Thus, the electric computer is suitable for obtaining a complete solution in four bridge-balancing operations subject only to the limitations involved in the use of the derived linear equations.

Problems to Be Solved in the Application of Microwave Equipment; *R. C. Cheek* (*Westinghouse Electric Corporation, East Pittsburgh, Pa.*).

The establishment of a microwave channel requires consideration of a number of different factors. Among these are the selection of the frequency band, selection of the sites for the terminals, the calculation of the free-space loss between the antennas and the choice of the antenna size, and the calculation of the other losses such as the loss between the transmitting and receiving equipment and the antennas.

For 50-foot path clearance over smooth spherical earth, the formula

$$h=\frac{d^2}{6}+50$$

gives with sufficient accuracy the antenna height in feet required at each terminal of a channel of length d miles. In the practical case, however, smooth spherical earth is rarely encountered, and it is usually necessary to make a profile drawing of the proposed route from topographical maps. Such a profile drawing can be corrected for earth curvature by the formula

$$y=\frac{2}{3}(dx-x^2)$$

where y is the correction in feet at a distance x miles from either terminal along the total path length d miles.

The free-space loss between two parabolic antennas is given approximately by the formula

$$\text{Free-space loss}=10\log_{10}\left(\frac{8\lambda}{\pi D_1 D_2}\right)^2 r^2 \text{ decibels}$$

in which λ is the wave length, r is the path length, and D_1 and D_2 are the transmitting and receiving antenna diameters, all in the same units. Calculation of total channel attenuation must include, in addition to the free-space loss, the loss between the microwave equipment and the antenna at each terminal. An additional allowance for fading of signals from free-space values, amounting to 0.5 decibel per mile of path length at 960 megacycles, and 1 decibel per mile of path length at 2,000 megacycles and 6,575 megacycles, is suggested.

Measurements and Tests on a Power-Line Carrier Relaying System; *R. H. Miller, A. R. Worthington* (*Pacific Gas and Electric Company, San Francisco, Calif.*).

In connection with the placing into service of a power-line carrier-controlled relaying system on the 220-kv transmission network of the Pacific Gas and Electric Company, staged fault tests were conducted to predetermine the satisfactory operation of the relay system. As a part of the fault tests, the operation of the carrier equipment was observed by obtaining oscillographic records of the times that the load and remote carrier transmitters were energized and de-energized with relation to the time of the initiation of the faults. Test equipment for this purpose consisted of the use of carrier-frequency voltmeters with special d-c amplifiers connected to the detector outputs so that the operation of the local and remote equipment be recorded on oscillograms.

Tests were also made to determine, if possible, the magnitude and distribution with frequency of carrier-frequency noise resulting from power arcs associated with faults.

Results of the tests indicated that most carrier-frequency interference occurs after circuit breakers at both ends of a faulted line have tripped and the line is discharging through the fault arc. Results of the measurement of noise interference indicated that for the bandwidth accepted by relay carrier receivers, the maximum noise voltage at the terminals of a receiver on a faulted 220-kv line would be in the order of a few hundred volts.

A Brief Pictorial Story on the Early Development of the Mercury-Arc Rectifier; *W. C. White* (*General Electric Company*).

Practically every electrical engineer interested in electronics knows about the contributions of Edison, Fleming, and deForest which mark the beginnings of the modern electron tube employing a thermionic cathode. In the case of the mercury-vapor tube with the pool cathode, however, very few engineers know about its beginnings and the names of the pioneers.

This paper traces this story from the occasion of the first demonstration of the mercury arc in London just 90 years ago through the early steps of the development. Just as the development of the incandescent lamp provided the beginnings of the thermionic cathode electron tube, the mercury-arc rectifier was a by-product in the search for an improved electric light, the mercury-arc lamp.

For 47 years, mercury-arc rectifiers have been a subject of discussion in AIEE meetings. This paper utilizes as far as possible illustrations with captions to follow the development of the rectifier. There are over 50 of these. The emphasis, as the title suggests, is on the early phases of the development. Except to illustrate the present form of some design trend, very little is included of the work of the past 15 years.

Pictures from several sources are included and are grouped under five main headings:

1. Early general development.
2. Tubes for battery charging.
3. The application to series arc street lighting.
4. The pumped-tank rectifier.
5. Reappearance of the sealed-tube type.
6. A few pictures of modern pumped and sealed rectifiers have been included to complete the story.

The author concludes with the opinion that the absence of radically new improvements and design features during the past 10 or 15 years may well provide an opportunity for competitive devices to narrow the field of application and prevent a further growth in volume of business for the pool cathode mercury-arc rectifier.

System-wide Fast Response Telemetering; *George W. Dupree (Southwestern Public Service Company, Amarillo, Tex.).*

Fast-response telemetering has been applied to the power system of Southwestern Public Service Company to provide all necessary information for normal and emergency load dispatching. The meters record total power generation and total reactive load for seven steam generating stations, the power to reactive flow in five major sections of 115-kv transmission line, and the power interchange at three connections to neighboring companies.

Torque-balance transmitters were used for totalizing and for short channels. Frequency-type telemeters with frequency-shift carrier were selected for the long channels. The longest channel is 380 miles. Speedomax instruments record line power readings to give indications of power swings for assistance in locating disturbances. Micromax recorders were selected for other readings. Totalizing was provided to record system generation, system load, and spinning reserve.

To provide a flexible system diagram, steel panels, similar to the meter panels, were installed. The diagram was placed on these panels with strips of rubber-cement backed paper tape for the lines and busses and gummed paper letters and figures for place and switch designations. Symbols for transformers and other devices were cut from wide strips of tape. Different colors were used for the various voltage classifications. Various sizes of Alnico magnets fitted with a color designation were used to show switch position and the status of generators. This use of magnets overcomes the necessity of punching or drilling holes in the steel panels.

Fast response telemetering has been applied on a system-wide basis to provide all necessary information with least present equipment and maximum adaptability for expansion. The fast response was chosen for its ability to follow rapidly changing conditions to give the dispatcher maximum knowledge of system conditions. Fast response recorders were used only where the extra expense was justified by the results to be obtained.

Electric Distribution in the Petroleum Industry; *Chance M. Hoag (The Fluor Corporation, Ltd., Los Angeles, Calif.).*

On account of the volatile, explosive, or flammable characteristics of many petroleum products, electric distribution design varies in some respects from that of conventional industrial plants. Underground distribution with manhole and duct systems is favored as compared with overhead distribution because of fire hazards. Underground systems in refineries follow conventional underground design and have proved more reliable over long periods of time than overhead construction.

Three-conductor lead-sheath cables are favored for the larger sizes as compared with single-conductor lead cables because of necessary derating resulting from sheath currents induced in single-conductor cables when operating with the sheaths in contact where two or more single-conductor cables are installed in one duct.

Continuity of service is in some respects more essential than in other manufacturing industries on account of complicated refinery units that require relatively long start-up periods after being shut down by power interruptance. Two separate circuits from the serving utility are recommended, with the necessary relay protection to provide continuous service. Secondary tie lines between refinery unit substations of either automatic or manual type of control provide additional protection in cases of primary feeder outage.

In the selection of motor voltages in the various horsepower classes, the most prevalent upper limit for 440-volt motors is in the order of 100 horsepower with 2,400 or 4,160 volts for motors over 100 horsepower. Motor-control equipment may be located in a nonhazardous area and general-purpose equipment utilized if properly housed. The equipment may be located in the hazardous area if a building or room is provided and pressured to prevent infiltration of flammable gas. If weather conditions permit, outdoor control equipment in National Electrical Manufacturers Association Type *4* may be installed if placed outside of hazardous areas, or NEMA Type *7* or *8* starters may be installed in the hazardous area. In refineries where the short-circuit rating is relatively high, starters in the 2,400- and 4,160-volt class are available for short-circuit ratings of above 50,000 kva.

In the design of natural gasoline plants where the only large motors are those driving the lean oil pumps, it is frequently more economical to operate all motors at 440 volts rather than to provide higher voltages for the two lean oil pumps.

Because of the many types of conductor insulation in the 600-volt class, it is recommended that an AIEE committee prepare a symposium on this subject.

Industrial Distribution; *Maynard R. Born (Shell Chemical Corporation, New York, N. Y.).*

An industrial distribution system must be reliable; continuity of service is paramount. Considering that distribution facilities represent roughly $1^1/_2$ per cent, 5 per cent, and 10 per cent of total plant investment in refineries, paper mills, and steel mills, respectively, there is small reason why the distribution system should not be as reliable as it is possible to make it. And this means that the expenditure of engineering time and talent necessary to make it so is justified.

The estimate of the load to be served is an important part of any industrial distribution study and too much care cannot be exercised in its preparation. Complete information is needed on the manufacturing process together with performance curves of the equipment. From these data an estimate of the net power input can be computed recognizing suitable demand, diversity, and load factors. The plant can then be divided into suitable load centers, and additional diversity factor as between load centers recognized.

After the load has been determined, the choice of distribution voltage can be made. A voltage as high as circuit-breaker maximum voltage ratings will allow is chosen with a maximum voltage rarely exceeding 13.2 kv. Generally, a voltage of 2.4 kv is chosen for systems with power supply under 10,000 kva whereas the voltage of 13.2 kv is used for systems to 25,000 kva or larger.

The radial system is usually chosen with possibly double radial feeders. Certain critical load centers may be interconnected through secondary selective circuits. Step-down transformers are used usually in series to obtain the use voltages of 2,400, 480, and 240/120 volts.

The industrial distribution system is a vital part of any industrial plant. If the flow of electric energy within a plant is inadequate to meet the demands of the manufacturing processes, the entire plant investment is threatened. The cost of power interruptions goes higher year by year with the greater dependence on electric drives and process control devices. Inflexibility and inadequacy of the power system can be restrictive to progress and profits.

Recent Developments in the Cathodic Production of Ferrous Metals in Soils; *I. A. Denison (National Bureau of Standards, Washington, D. C.).*

Corrosion of underground structures, such as pipe lines, often takes the form of highly localized attack with the development of pits, which under certain soil conditions ultimately perforate the pipe wall. To combat this condition, pipe lines in corrosive soils are usually coated with a variety of bituminous materials, which reduce but do not always prevent the occurrence of leaks. A standard practice in the pipe-line industry is to supplement the protection afforded by coatings by the application of electric current, the process being known as cathodic protection. This means of combatting corrosion is not limited to structures protected by coatings, but is being applied successfully to underground installations which otherwise are unprotected from corrosion.

In protecting underground structures cathodically, direct current is customarily applied in amounts which will cause a high-resistance voltmeter connected between a copper–copper-sulfate electrode and the structure to indicate a value of 0.80 to 0.85 volt, the reference electrode being connected to the positive terminal of the meter. Whether corrosion is actually prevented by this procedure or whether the corrosion rate is merely reduced to a value that can be tolerated has not been demonstrated except under local conditions. On many pipe-line systems, a moderate number of leaks each year can occur without various interruptions of service or undue financial loss, but on pipe lines transporting inflammable or explosive fluids in congested areas, even a single leak might lead to considerable loss of valuable fuels and property damage. Under these latter conditions, it is essential that cathodic protection be 100 per cent effective, without at the same time requiring undue quantities of electric energy.

Theoretically, ferrous metals should cease to corrode in soils and in other natural environments if their potentials can be brought by the application of current to some undefined critical value. In the course of its investigation of cathodic protection in soils, the Underground Corrosion Section of the National Bureau of Standards has undertaken to assign a value to this critical potential which would be valid for all soil conditions. The validity of this "protective" potential was then confirmed by measurements of weight loss of electrodes maintained at this potential while exposed to severely corrosive soils.

Because of the relatively high resistance of soils and the relatively large differences in potential associated with soil corrosion, accurate measurements of the potential of underground structures to which current is being applied are made with considerable difficulty. By means of improved measuring circuits and instrumentation in the course of development at the Bureau, it will be possible to measure readily the potentials of underground structures free of voltage drop, which would be expected to facilitate the application and maintenance of cathodic protection systems.

The Mining, Concentrating, Smelting, and Refining of Copper; *R. J. Corfield* (*Kennecott Copper Corporation, Garfield, Utah*).

Because of the wide use of copper in the electrical industry it is believed that a paper covering the subject from mining to refining will be of interest to electrical engineers.

The Kennecott Copper Corporation is now completing an ultramodern refinery for semifinal processing of copper-bearing ore from the open-cut mine at Bingham. This refinery will be initially capable of refining approximately 300,000,000 pounds of copper annually.

The refining of copper is among the oldest of the arts and the basic process remains about the same; however, the equipment to accomplish the processing has been greatly improved. A number of new devices will be in operation at this refinery, among them specially built anode cars in which anodes will be racked in such a way that they may be handled by overhead cranes directly from car to electrolyte cell.

The current input to the electrolyte cells will be precisely controlled by Amplidyne-Amplistat field regulation of the generators, the 2,900-horsepower 13.8-kv synchronous motors driving the generators will be started at full voltage, and the sets will run in an air-conditioned room where temperature and humidity can be accurately controlled to insure good commutation and brush life.

The main busses for transmitting 16,000 amperes to the commercial cell lines consists of eight one-half-inch by 10-inch copper bars; all joints are lap type, silver-plated, and clamped rather than bolted. The low current density of 400 amperes per square inch will result in low losses and temperature.

A specially designed, photoelectrically controlled cathode charging machine will be used ahead of each electric melting furnace and should result in more uniform melting and at the same time eliminate considerable manual handling of cathodes.

Electric arc furnaces and low-frequency induction furnaces are conventional and are equipped with the latest type of automatic control.

Casting wheels are conventional except as regards driving motors and control. Ordinarily, variable-voltage d-c motors are used for this application. In this case, a-c motors with electronically controlled, built-in eddy-current clutches will be used. This type of drive is expected to be just as satisfactory and less expensive to maintain.

Primary power distribution is by means of single-conductor rubber-insulated neoprene-jacketed cables supported by micarta blocks on angle-iron racks. Cables will be installed in tunnels. This is a departure from the practice of using 3-conductor varnished-cambric insulated lead-covered cable in duct banks. Double-ended unit substations with bus tie assure continuity of service to all auxiliaries, an important requirement in a refinery.

Radio-Frequency Power Supply for a 500-Kv Ion Source; *John R. Woodyard* (*Radiation Laboratory, University of California, Berkeley, Calif.*).

A half-million-volt d-c power supply is required for accelerating the proton beam before injection into a linear accelerator where it is further accelerated to ten million volts prior to injection into the Berkeley Bevatron.

Because of the linear accelerator the voltage stability requirements are rather severe. The voltage must be held constant to within 500 volts out of 500,000 while delivering currents of several milliamperes. In order to keep the power supply within reasonable dimensions, it was decided to use a cascade rectifier with radio-frequency input. Although the choice of frequency is not critical, the optimum is in the vicinity of 100 kc. Much lower frequencies cause the apparatus to become bulky and frequencies above half a megacycle cause the stray-capacity currents to become intolerable.

The circuit is that used by Cockroft and Walton in 1930 at power frequencies. Twenty-six stages are used in cascade. The required voltage stability is obtained by an electronic voltage regulator in the ground lead.

For convenience it was desired to work at atmospheric pressure and to keep the longest dimension of the power supply to six feet. Because of space limitations and the low dielectric strength of air at atmospheric pressure the rectifier itself is oil-filled. For ease in servicing, the 26 stages are broken up into 13 units, so that any unit can be quickly replaced by a spare in case of breakdown.

Each unit consists of two type-*8013A* rectifier tubes, two 0.016-microfarad 40-kv capacitors, and one filament transformer, all contained in a cylindrical lucite case approximately 12 inches in diameter and 6 inches long, which is filled with transformer oil. The oil is circulated for cooling purposes through a heat exchanger at ground potential via a lucite plumbing system.

In order to heat the rectifier-tube filaments which are at high voltage above ground, a cascade connection of radio-frequency isolation transformers is used. These transformers use toroidal cores made of a newly developed ferrite which is a homogeneous ferromagnetic insulator. The rectifier has performed very reliably at 500 kv. It has been in operation for one month without a high-voltage breakdown.

This work was performed under the auspices of the United States Atomic Energy Commission.

Determination of the Composition of Surface Layers by Ion-Scattering; *S. Rubin, A. M. Zarem* (*Stanford Research Institute, Los Angeles, Calif.*).

The application of high-voltage ion beams to the chemical analysis of very minute quantities of material is described. By the use of apparatus and techniques developed primarily for nuclear research, it is possible to determine the proportions of the elements present in a sample as small as a fraction of a microgram.

The method is based on the analysis of the differences of the velocities of initially monoenergetic ions, usually protons or alpha particles, after they have been scattered by the various nuclear masses in the sample. These velocity differences are very small, so that the accelerating voltage must be constant to a very small tolerance, and the analyzing apparatus must be capable of very high resolution.

For best results it is necessary to use ions accelerated to about 0.5 to one million electron-volts energy. This high energy is required to achieve sufficient penetration of the target by the charged nuclei with which it is bombarded. A highly regulated electrostatic generator is used to accelerate the ions, with the regulation of voltage based on the deflection of the ions by a lower constant deflecting voltage.

The scattered ions are analyzed by means of a magnetic spectrometer, which bends them in curved paths and refocusses them at an ion detector. The position of the focus depends on the ion velocity, so that the complete velocity spectrum of the scattered ions can be measured by moving the detector, or more commonly, by varying the magnetic field.

Some preliminary experiments performed with existing apparatus have demonstrated the feasibility and utility of the method. For maximum resolution, greater voltage regulation is required than is now available, and with other changes in apparatus design to provide optimum conditions for this type of measurement, it is felt that new equipment should be constructed in order to use this method as a practical analytic tool.

A Review of Instruments and Practices for Insulation Resistance Measurement; *W. G. Foster* (*Portland General Electric Company, Portland, Oreg.*).

In many instances the policy of insulation testing in the field has suffered because of lack of suitable information for testing personnel. More information is needed on the seven factors which affect the insulation resistance of absorbent materials. These factors are: type and volume insulation; insulation temperature; insulation moisture content; test voltage applied; time duration of test; cleanliness of surfaces; humidity of surrounding air.

In the discussion of these factors emphasis has been placed on the effect of test potential. Since Evershed's' research in 1913 on the interrelated effects of test potential and moisture content, insufficient information has reached the field tester to allow him to employ the 2-voltage test to determine moisture content. When this test is utilized in conjunction with the usual dielectric absorption test, the causes of low-resistance readings became clear and the proper maintenance program can be prescribed.

The adaptability of commercial insulation testers is important to the testing technique. For the best results the instrument should have two testing voltages available which differ by a factor of four. The test voltage supply must have good regulation in order to maintain accuracy of measurement.

Output Analysis and Alignment Techniques for Phase-Rotation Single-Sideband Transmitters; *Oliver Whitby, Donald R. Scheuch (Stanford Research Institute, Stanford, Calif.).*

Growing interest in single-sideband transmission, as well as several new practical realizations of wide-band, audio, 90-degree phase-difference networks, have made desirable and practical the phase-rotation high-level scheme of single-sideband generation. Two grid-modulated balanced modulators with parallel outputs are made to have both the radio-frequency drive and the modulating voltages in quadrature between the two modulators in this system. At the present stage of development, such transmitters, in sizes up to one-half kilowatt output, can be made as free of distortion products as those which generate the single sideband at low level followed by linear amplifiers. The relative simplicity of the phase-rotation scheme, and the fact that a definite and unambiguous alignment procedure is now available, are very strong points in favor of the high-level system.

There are three main types of misalignment which can occur in such a transmitter. These result: because of unbalance in the drive or modulation voltage or in the tube characteristics within either of the modulators; because of inequality between these quantities in the two modulators; or because of departure from the 90-degree phase-difference relationship which must obtain between the two modulators in both modulating and radio-frequency drive voltages.

When a misaligned phase-rotation transmitter is modulated by a single sinusoidal tone of frequency f there will appear in the detected output a definite audio-frequency component which may be unambiguously identified with each type of misalignment. Unbalance within a modulator gives rise to a component f or f + 90 degrees, depending on the modulator which is out of adjustment. Improper operation between modulators will yield a $2f$ or $2f$ + 90 degrees component. A phase-sensitive detector, suitably gated in coherence with the tone modulating the transmitter, can be made to respond to only one of these components in the output of the transmitter. With the aid of an Alignment Indicator, composed of four such detectors, a definite alignment procedure may be established for properly adjusting a high-level phase-rotation single-sideband transmitter. Standard methods of sampling the output spectrum of the transmitter, by means of a receiver and audio-wave analyzer, have shown the Alignment Indicator, using four phase-sensitive detectors, to yield excellent results quickly.

Development of an Integrated Power-Line Carrier Telephone System; *H. S. Lane (Pacific Gas and Electric Company, San Francisco, Calif.).*

The use of power-line carrier telephone on the Pacific Gas and Electric Company system developed from its crude and limited beginnings in 1922 to its present status, comprising 24 channels with 53 terminals on some 1,850 miles of transmission lines from 70 kv to 220 kv. For greater flexibility and reliability of service and to make the most beneficial use of the investment, these circuits are integrated with the many thousands of miles of other telephone lines and hundreds of switchboards of the company's private telephone system.

Investigations have been made through the years of the major problems of the application in this system of the various types of equipment (single- and double-frequency duplex, amplitude modulation, frequency modulation, single sideband, couplers, traps, signalling, and so forth). Conclusions are given, and recommendations are offered for modifications in the design and application of such equipment to improve quality and reliability of service, conserve frequencies, apply the proved practices of the communication industry, and ultimately effect over-all economies.

A Commutatorless Pilot Exciter for Turbine Generators; *C. Lynn (Westinghouse Electric Corporation, East Pittsburgh, Pa.), D. R. Patterson (Pennsylvania Electric Company, Johnstown, Pa.).*

Voltage stability of self-excited commutating-type exciters for turbine generators when operated at low excitation is hazardous under hand control. Automatic voltage regulators of the contact-making type eliminate this hazard, but have relatively slow response. Assurance of stability requires operation at points with some saturation in the magnetic circuit. Special shaped saturation curves secured by various types of notching of the main poles will reduce the voltage point where instability is reached.

Complete stability and improved voltage response under regulator operation can be secured by separately exciting the turbine generator exciter, usually from a direct-driven pilot exciter.

Improved reliability from the standpoint of continuity of service results whenever contacts are eliminated. Maximum reliability is secured by building the pilot exciter in the form of a permanent-magnet 3-phase a-c generator, and rectifying the output by means of a tube or dry-metallic-type rectifier. Improvements in the design of such a generator have resulted in extreme reliability for any capacities necessary for turbine-generator pilot excitation. Possibilities of voltage regulation obtainable with a magnetic amplifier working from permanent magnet pilot exciter may result in only one set of contacts on a turbine-generator excitation system, the brushes and the commutator of the main exciter.

The Design of the Bevatron Magnet; *Duane Sewell (Radiation Laboratory, University of California, Berkeley, Calif.).*

The magnet for the Bevatron (proton synchrotron) that is being constructed at the University of California at Berkeley has been designed from the experience which was gained from tests on 1/12-scale d-c and pulsed model magnets and from the operation of a quarter-scale model of the entire machine.

The magnet will be built in the form of a ring that is divided into four quadrants which are spaced 20 feet from one another at the ends. The ring will have a rectangular cross section 10 feet high by 21 feet wide. The quadrants will be built on a $48^1/_2$-foot radius to the center line of the gap which means the over-all distance across the magnet will be about 135 feet.

Ninety-seven hundred tons of one-half- and one-quarter-inch thick mild steel plate are required for the magnet. These plates are being bolted together in $2^1/_2$-degree sections; the sections will then be assembled to form the entire magnet. The plates outside the vacuum tank are being insulated from one another with 0.020-inch thick cardboard; those inside will be insulated with baked enamel.

The exciting coils will be wound with 137,500 feet of 1,678,000 circular-mil copper cable insulated with varnished cambric. Each quadrant of the magnet will have individual exciting windings which will be connected externally to form the desired circuit. The coils will be held in place by molded bakelite spacers and clamps which will give the desired spacing so that cooling air can be circulated around each wire. Some 560,000 cubic feet per minute of cooling air will be fed from two 250-horsepower blowers to the magnet through ducts in the floor.

The air gap in the magnet through which the protons travel while they are being accelerated will be two feet high by eight feet wide. This region will be enclosed by a stainless-steel tank that is an integral part of the magnet structure and the whole region will be evacuated to a pressure of the order of 10^{-6} millimeters of mercury.

The magnet will be pulsed ten times per minute with the current rising from 0 to 8,333 amperes in $1^3/_4$ seconds. The magnetic field in the air gap will rise at an initial rate of 6,600 gauss per second; this rate will fall gradually to 4,000 gauss per second at the peak current. The peak field in the air gap will be 9,800 gauss.

The inductance of the magnet will vary from 4.15 henrys at 200 amperes exciting current to 1.3 henrys at 8,333 amperes. The total resistance of the exciting coils will be 0.267 ohm at 65 degrees centigrade. The peak required kilovolt-amperes will be 100,000 kva while the time average power dissipation will be about 3,500 kw. Some 230 kw of this power will be dissipated by eddy current and hysteresis losses in the steel. The peak stored energy in the magnet field will be about 80,000 kilowatt-seconds.

The initial excitation voltage will be 18 kv and this will drop to 12 kv at peak current at which time the voltage drop will be about 2,200 volts.

The $2^1/_2$-degree stacks of steel plates for the magnet are being assembled at the present time. Plans call for the steel erection to start late this summer. This work performed under the auspices of the Atomic Energy Commission.

Frequency Control for the Bevatron Radio-Frequency Voltage; *Jack Riedel (Radiation Laboratory, University of California, Berkeley, Calif.).*

The radio-frequency voltage used to accelerate the proton beam in the Bevatron is initially derived from an *LC* oscillator operating at low level. The frequency of this oscillator must cover the range from 350 to 2,500 kc per second as the magnetizing current goes through the range from 200 to 8,300 amperes. During this time the frequency-versus-current relationship required to accelerate the proton beam must be accurately maintained to within 0.05 per cent.

The variable element in the control

oscillator is a saturable inductance, consisting of toroidal coils wound on Ferroxcube III, a ferromagnetic ceramic. This material has relatively high Q's at radio frequencies and is capable of being easily saturated through a permeability range of 800 to 1. The saturation in this case is accomplished by diverting a portion (five per cent) of the Bevatron's magnetizing current through a one-turn winding around the toroids. The fixed circuit parameters of the oscillator are adjusted in such a way as to cause the frequency to track the saturating current in the required manner. Long-time stability is achieved by temperature regulating the various temperature-sensitive circuit elements.

The output of the low-level control oscillator is fed to a self-tuning amplifier circuit. This self-tuning is accomplished by using a Ferroxcube III saturable inductance in the resonant output circuit and continuously adjusting the saturating current through it by means of an automatic phase-detecting feedback circuit.

The output of this amplifier is used to drive the final power amplifier, which incorporates this same self-tuning feature in its output circuit. The output voltage from this final amplifier is applied to the beam-accelerating electrode, which consists of a hollow rectangular cylinder 11 feet long with a cross section of two by five feet. The beam in passing through this cylinder is accelerated by a potential difference of approximately 1,100 volts out of a total of 20,000 peak to peak volts applied to the electrode.

This general method of frequency control is the same as that used on the quarter-scale model Bevatron which operated successfully during the summer of 1949. The work is being done under the auspices of the United States Atomic Energy Commission.

Electrification of a Pulp Mill and Board Machine; *J. A. Tudor (Westinghouse Electric Corporation, Portland, Oreg.), A. F. Weleber (Weyerhaeuser Timber Company, Springfield, Oreg.).*

Power is generated by two steam turbo-generators. One is a 9,375-kva 11,500-volt 80-per cent power factor 3,600-rpm generator; the other is a 6,250-kva 11,500-volt 80-per cent power factor 3,600-rpm generator. Both generators are connected to a 12,000-volt bus through air-break totally enclosed draw-out-type metalclad switchgear. Similar circuit breakers are used to connect the 12-kv bus to plant feeder and also to the power company.

A radial system of power distribution was selected for simplicity of operation. To gain maximum economy self-supporting aerial feeders were used to supply the four outdoor substations.

Fourteen 750-kva transformers, two 500-kva, three 100-kva, and three 50-kva transformers are used to transform the 12,000 volts down to the usable voltages of 2,300, 440, 220, and 110 volts. All transformers are oil-insulated self-cooled.

The connected motor horsepower is approximately 12,000 horsepower, and to assure high power factor, maximum efficiency, feeder economy, and voltage stability, 35 per cent of this horsepower is synchronous motors. Most motors used in the mill were of splashproof construction. All motors above 100 horsepower are 2,300 volt and those 100 horsepower and lower are 440 volt.

The new 160-inch Fourdrinier 13-section paper machine is driven by a modern electronically controlled multiple-generator sectional drive designed to operate over a speed range of 200 to 1,000 feet per minute.

Individual, totally enclosed force-ventilated d-c motors are applied to the machine sections. Each of these motors is connected to individual electronically regulated d-c generators.

Accurate speed cue is obtained from an inductor-type cue tachometer. The tachometer armature and field windings are in the stator eliminating the use of commutators, slip rings, or brushes.

The speed cue is rectified and matched to a d-c reference in the sectional regulator detector circuits. Any differences are amplified through three stages of amplification. The output of the final stage or the power amplifier is applied to the sectional generator field. An armature voltage change modifies the speed error quickly and accurately until the speed cue satisfies the requirements of the detector reference circuit. Current limit, antihunt, inertia compensation, and stability adjustment is provided to give motor protection and reliable speed regulation under varying load conditions.

Survey of Operation of Mercury-Arc Rectifiers; *AIEE Committee on Electronic Power Converters.*

In 1949 the Application Subcommittee of the AIEE Committee on Electronic Power Converters sent questionnaires to all users of mercury-arc rectifiers in America. For the purpose of this survey, the users were divided into three classifications:

1. Mining, steel, and general industrial service.
2. Electrochemical service.
3. Railway transportation service.

Although the questionnaires for each classification were similar, the details were varied somewhat to conform with the type of service.

Questionnaires were sent to a total of 656 users of which about 80 per cent were in the mining, steel, and general industrial service group and 10 per cent each in the other two groups. Approximately 25 per cent of the users completed and returned the questionnaires; however, these returns represent almost half of the estimated total installed capacity.

The returns indicated that in general rectifier operation had been very satisfactory in all three classifications. Small units under 1,000-kw rating with sealed tube ignitrons predominated in the mining, steel, and general industrial service, while longer pumped units of both ignitron and multianode types were most prevalent in the transportation and electrochemical service. There appeared to be a decided trend away from the multianode and to the single-anode type. Also, the use of sealed tubes in the larger units (above 1,000-kw rating) has begun, in an effort to further reduce maintenance and operating costs by eliminating the evacuating equipment.

The serviceability of all types of rectifiers has been very good with an average yearly outage of 0.8 per cent or 70 hours per unit for all types. However, the reliability of the ignition system of the ignitron-type rectifiers should be improved considerably since this component caused a more-than-average amount of trouble.

Very little electrolysis trouble was reported as the use of target rods had apparently been very effective in eliminating this difficulty. Also, telephone interference problems were very few even with the very large capacity installation in the electrochemical industry.

Spare parts stocks kept by users varied considerably depending upon the importance of the service. In the electrochemical field a complete supply of parts and supplies is kept since the rectifiers in this field are usually continuously loaded. Users of the smaller sealed-tube type rectifiers in general carried only spare tubes and dry-type rectifiers.

An Electromagnetic Induction Method of Measuring Oscillating Fluid Flow; *A. J. Morris (Office of Naval Research, San Francisco, and Stanford University), J. H. Chadwick (Stanford University).*

The flowmeter described is used for a study of the dynamic characteristics of a variable-pitch blade pump as a function of frequency and of time. Requirements to be met by this flowmeter are severe due to the wide range of flow velocities covered and due to the fact that the system in which the flow is taking place is accelerating as is the fluid. The choice of an electromagnetic induction-type flowmeter was based on its linearity, the fact that it is instantaneous in response, and its independence of the physical properties of the fluid. The principle of the flowmeter is that of Faraday's law of induction. A strong magnetic field is established through the region of water flow. The fluid acts as a group of filamentary conductors and will have induced in it a voltage proportional to the mean velocity of flow and the magnetic field strength. The polarization problem in such an instrument is discussed. It is decided that since the flow is oscillating, polarization will not be troublesome. Construction of the flowmeter is described and expected performance discussed. Problems of bias voltages and noise voltages are treated. The associated instrumentation required to record the flow signals is described. Results of tests of the flowmeter yield the following:

Sensitivity	—1.22 mv per foot per second
Linearity	—2.5-per cent maximum deviation from straight line (within experimental error)
Phase lag	—0 degrees in flowmeter itself
	5 degrees up to 1/2-cycle per second in associated instrumentation
Drift	—0.044 mv per minute at 0.3 cycle per second
	0.127 mv per minute at 0.03 cycle per second

MADDIDA; *Floyd G. Steele, Donald E. Eckdahl (Computer Research Company, Manhattan Beach, Calif.).*

Two devices are normally used to simulate the process of integration: the analogy integrator and the numerical accumulator. It is possible by employing a particular

numerical technique to produce a device having the logical characteristics of an analogy integrator and the accuracy and repeatability characteristics of the numerical device. A set of these digital integrators may be intercoupled in the manner natural to the ordinary Differential Analyzer to solve ordinary differential equations or sets thereof, either linear or nonlinear.

"MADDIDA" (Magnetic Drum Digital Differential Analyzer) is one particular realization of a set of these digital integrators using electronic digital techniques. Integration is accomplished by operating on pairs of numbers by an additive transfer process. A register n digits in length containing a number y is added into a register R of equal length upon each occurrence of an input pulse dx. All carries from register R are used as incremental outputs dz. The number in y can be increased or decreased by an input dy. The result is that $dz = \frac{y\ dx}{Bn}$ where B is the base of the number system used.

MADDIDA stores the registers mentioned on a magnetic drum and operates on each pair of numbers serially. A pair of numbers is called an integrator. The machine contains 22 such integrators and a system for general intercoupling of the integrators.

The machine contains 60 vacuum tubes including those used in the memory. Additional tubes are present in the four regulated power supplies. Some 1,000 germanium diodes are used for logical operations and for clamping and coupling on the flip-flops.

Electric Power Distribution at a Synthetic Ammonia Plant; *A. M. Selvey, A. F. Zagar (Shell Chemical Corporation, Pittsburg, Calif.).*

To attain a degree of adequacy commensurate with imposed chemical manufacturing requirements and reasonable capital outlay in relation to over-all plant investment, the design and layout of power-distribution facilities must be conceived and executed to suit production and operating conditions and environmental circumstances. Service continuity at the Shell Point plant of the Shell Chemical Corporation, Pittsburg, Calif., is aided first in the layout of the distribution system by segregation or integration of load areas in accordance with the desired degree of process independence, and then by the installation of reliable, quality equipment duplicated as widely as feasible and backed up by an adequate stock of spares. Alternate sources of power allowing for quick restoration of service are provided through the use of looped radial feeders to interconnect load centers. Protective devices for process-sequence and overload control are provided for continuous chain of process operations. Corrosion and explosion hazards are overcome through the use of totally enclosed weatherproof equipment located outdoors in areas removed from pernicious elements, or by installing separate vaults supplied with washed and filtered fresh air. Explosionproof equipment is installed in areas classified by code as hazardous. Safety of personnel and of property requires extensive use of metalclad switchgear, totally enclosed insulated bus bars, interlocked circuit breakers, and an underground distribution system. Key interlocks remotely controlled from a central location are used to obtain quick emergency shutdowns.

Good familiarity with standardized equipment along with a program of training and education of electricians makes for a good safety record. Preventive maintenance performed at regularly scheduled intervals or during planned plant shutdowns goes far towards minimizing unpredicted equipment failures with their attendant loss of chemical production. Electric system operation involves mainly arranging a normal, reliable method of supplying power backed up by alternate feeds for use in an emergency. Simplicity of design and layout in the long run makes for high reliability and maximum service continuity.

Safety Tests for Electronic Devices; *O. G. Wedekind (Underwriters' Laboratories, Inc., San Francisco, Calif.).*

It is possible to incorporate safety in the design of electronic devices with the least additional cost by considering fundamental safety concepts during the product development stages. Reference to the National Electrical Code will provide much data on installation requirements. The interior design features are not subject to review by authorities enforcing installation requirements and are judged on the basis of the tests and considerations outlined in this paper.

A fire, shock, or casualty hazard should not develop in electronic equipment by reason of normal operation in the intended manner nor under conditions of probable abnormal operation. Testing methods are as follows:

1. *Input Tests, Rating.* Equipment should be marked to assure use on circuits of proper rating.

2. *Heating Tests.* Tests should be made on components to assure the use of materials at temperatures which will assure reasonable life when equipment is installed, loaded, and used in a normal manner.

3. *Overload Tests.* Overload tests are employed to obtain a quick evaluation of component performance. A limited number of operations, such as 50, will usually suffice, and the condition of overload depends on the function of the product. Contacting devices are tested on 150 per cent of rated current. Mechanical devices are tested by appropriate physical overloads as measured by electrical input.

4. *Endurance Tests.* The mechanical and electrical stability of an assembly are best evaluated by an endurance test consisting of continuous operation at some rate which does not affect the performance.

5. *Dielectric Strength Tests.* The adequacy of insulation and spacings is judged by application of a test potential for a period of one minute. Potentials employed are related to circuit potential by some predetermined factor.

6. *Shock Hazard.* Hazard from shock at exposed parts is presumed where available current exceeds five milliamperes through 500 ohms resistance and for frequencies from zero (d-c) to 60 cycles.

7. *Special Tests.* Special tests may be found necessary where unusual equipment or constructions are involved.

8. *Construction.* The over-all construction of the product should be adequate from the standpoint of shock, fire, or casualty hazards and should provide mounting and connection facilities.

By carefully considering safety features concurrent with other product design problems, important savings in development cost are possible. A product engineered for safety has definite advantages in sales appeal.

Electrical Work Injuries in California Industries (1940–1949); *E. E. Carleton (Department of Industrial Relations, San Francisco, Calif.).*

One out of every 13 electrical work injuries requiring medical attention results in death, according to California figures for 1940–49. The annual average for the 10-year span is 485 such injuries, including 38 deaths. Contact with overhead high-voltage lines provides the greatest single cause of fatalities.

A large proportion of injuries results from the attempts of inexperienced employees and novice electricians to make electrical repairs and adjustments. Misapplication of electrical material and equipment is another major cause.

Failure to look for and correct defects also contributes heavily to injuries. Defective cords with bare spots or protruding strands should be not merely discarded but destroyed, or they may eventually find their way back into service. Rubber deteriorates and becomes brittle with age. Plugs break and expose live parts.

Another cause of injuries is the improper use of motor branch-circuit disconnecting switches as motor control devices. Switch explosions cause many painful injuries.

Electrical accidents and injuries will be greatly reduced if only safe equipment and apparatus is used, is installed properly, and is maintained in good condition, and if live parts are not exposed to contact or mechanical injury. It will be necessary, too, for everyone in electrical work to maintain safe practices and be constantly vigilant against performing an unsafe act. There must be a continuing and increasing interest in safety in electrical installations, from the design engineer to the workmen engaged in installing, operating, or repairing.

Design Features of the National Bureau of Standards Western Automatic Computer; *E. Lacey, D. F. Rutland, H. T. Larson, H. D. Huskey (National Bureau of Standards, Washington, D. C.).*

The National Bureau of Standards Western Automatic Computer is now in the testing stage. It is an extremely fast (16,000 additions and 2,500 multiplications per second) automatic sequenced electronic digital computer.

The high-speed memory makes use of cathode-ray tubes operating on a principle discovered by F. C. Williams of Manchester University, England. This memory unit is parallel with 41 binary digits per work or number. The arithmetic unit also operates in a parallel mode. The net addition time, which is about five microseconds, is determined by the time required for carry through to take place in respect to all of the 41

digits. The computer operates in a synchronous manner, the full five microseconds being allowed for each addition whether carry takes place or not.

The Williams-type memory requires regeneration, and this process is carried on during alternate 8-microsecond intervals. During the other 8-microsecond intervals, operands are transferred from the memory to the arithmetic unit, results are transferred back to the memory, and the next command is transferred to the control unit.

The arithmetic unit performs the operations of addition, subtraction, both rounded-off and exact multiplication, compare (changes the course of the computation depending on the relative sizes of two numbers), and extract (divides numbers up into parts which the computer can then handle in different ways). More elaborate operations than these are accomplished by routines of commands stored in the memory. Such routines are called into action by use of code words. This procedure simplifies the process of preparing problems for the computer. For example, large systems of equations, say 100, require giving less than 30 instructions to the computer.

The initial input-output equipment consists of electromatic typewriters using punched paper tape. Routines for solving standard problems will be established on tape, and stored in a "library." Thereafter, solution of another problem of that type only requires that the new parameters, or coefficients, be punched on the tape and fed into the computer.

An auxiliary memory consisting of a magnetic drum is being added to the computer, increasing considerably the computer's total storage capacity. A magnetic tape input–output unit is also being added to the computer.

This computer is located at the Institute for Numerical Analysis, which is a section of the National Applied Mathematics Laboratories of the National Bureau of Standards, situated on the campus of the University of California at Los Angeles. The computer was financed by the Office of Air Research.

A Water Rheostat Using Untreated Water; *J. F. Engle (Oregon State College, Corvallis, Oreg.).*

A water rheostat using untreated water has been designed and built by the Department of Electrical Engineering at Oregon State College to meet the needs of power machinery and other heavy equipment laboratories. This rheostat is rugged, compact, flexible, continuously adjustable, and suitable for use in either d-c or single- or 3-phase a-c low-voltage circuits. The laboratory uses for this single rheostat are: d-c motor starting, d-c motor speed control, d-c and single- and 3-phase a-c loading, wound-rotor induction-motor speed control, and many other applications.

Each rheostat consists of a 7-electrode assembly held stationary within a single tank, and the resistance is varied by changing the water level with respect to the electrodes. The rheostat tank and electrodes are made of austenitic 18–8 chromium-nickel stainless steel. The 7-electrode assembly is connected to make a balanced equivalent delta resistance when used in a 3-phase circuit. The electrolyte used in the rheostat is untreated city tap water which has an average resistivity of 4,600 ohms per cubic inch at 20 degrees centigrade.

The water level is changed by a positive-displacement-type pump driven by a 115-volt 3-phase induction motor. Reversing contactors in the driving motor circuit allow the water level, hence the resistance, to be controlled from any laboratory in the Electrical Engineering Building by the use of a 3-wire control circuit. To facilitate remote control, each rheostat is equipped with electrodes to limit the upper and lower water levels. Remote control is accomplished with a 3-wire push-button station that has pilot lights to indicate when either water level limit has been reached in the rheostat. Any number of rheostats may be operated in parallel from one or more push-button stations, or one rheostat may be operated by any number of push-button stations without the use of special equipment.

Potentials ranging from zero to 300 volts can be satisfactorily handled by the rheostat. With 230 volts three phase applied, a single rheostat unit will dissipate 75 kw, although the measurements of the tank are only 14 by 27 by 36 inches high. With 77 volts three phase applied to the rheostat, the maximum power dissipated in a single rheostat is 10 kw.

Eight of these rheostats are now completed and in operation, and the successful performance of the initial installation warrants the construction of additional identical units as needed.

Electric Analogue Computing Techniques for Complex Vibration and Aeroelastic Problems; *G. D. McCann, R. H. MacNeal (California Institute of Technology, Pasadena, Calif.).*

Suitable electromechanical analogies have now been developed for the general representation of all forms of "lumped" and "distributed" elastic media.[1,2] These have now been applied, on the California Institute of Technology electric analogue computer, to a variety of aircraft structure vibration analyses including landing shock, taxiing shock, and aeroelastic vibrations such as required for flutter and gust loading studies. This provides a powerful tool for general design analysis of aircraft. Now, for the first time, the complete elastic structure can be set up in great detail. Motions and stresses in each element of the structure can be completely recorded not only for static loading conditions, but also for the very complex transient conditions such as for flight under gust loading. All of the elastic parameters of the aircraft are directly represented by electrical parameters which can be quickly varied to study for design analysis purposes.

Such elements as wings, fuselages, and stabilizers can be represented on the computer either as beams with combined bending and torsion or variable thickness plates. The beam equations are set up in finite difference form and direct current and voltage analogies exist for bending deflections, slopes, angles of twist, bending mounts, shears, bending loadings, torques, and torque loadings. The electric circuits which have been developed to represent the aerodynamic forces on wings, control surfaces, and so forth, can be used for the loading of a large number of the finite difference cells.

Comprehensive studies have been made to determine the accuracies of the computing techniques. Also, in co-operation with the Douglas Aircraft Company, correlated calculations and airplane "shake" tests have been made to develop accurate methods of determining the probable elastic parameters to be used in the electrical analogies.

REFERENCES

1. Beam Vibration Analysis With the Electric Analogue Computer, **G. D. McCann, R. H. MacNeal.** *Journal of Applied Mechanics* (New York, N. Y.), volume 17, March 1950, page 13.

2. The Solution of Elastic Plate Problems by Electrical Analogies, **R. H. MacNeal.** *Journal of Applied Mechanics* (New York, N. Y.), paper number 50-SA-23.

Selection, Application, and Operation of Large Power Transformers on the Southern California Edison Company System; *C. L. Sidway, L. H. Beebe (Southern California Edison Company, Los Angeles, Calif.).*

In the selection, application, and operation of large power transformers, the Southern California Edison Company considers dependability and continuity of service most important. Single-phase 2-winding self-cooled units predominate, and spare transformers are provided for all major installations. Three-phase transformers are used only if a unit failure will not cause a service interruption.

For greater reliability, terminal boards are used in lieu of tap changers for de-energized operation. Transformer bushings are required to meet rigid specifications. Those for the higher voltage classes are interchangeable among different makes of transformers. All transformer cores are removed for inspection upon receipt, and bolted, not welded, covers are specified. Oil preservation is provided by sealed tank construction up to 2,000 kva and under 16.5 kv, inert-gas oil-sealed system for over 2,000 kva and 33 kv and above, and inert-gas pressure system for all capacities of 220- and 230-kv transformers.

Full insulation is required. Lightning arresters are not normally used on 220-kv transformers. Protection is by differential or overcurrent and differential relays. The 69-kv and 220-kv system are operated solidly grounded.

Careful application of these practices has resulted in exceptionally dependable service and economical operation.

Application of Analogue Computers to Aeroelastic Problems; *P. A. Dennis, D. G. Dill (Douglas Aircraft Company, Inc., El Segundo, Calif.).*

Engineers of the Douglas Aircraft Company, Inc., have solved one of the more difficult problems in aircraft design by the application of the California Institute of Technology's Analogue Computer: the dynamic behavior of the airplane considered as an elastic structure when subjected to aerodynamic forces, which themselves depend on the time history of the airframe deflections. This computer has been used to represent the entire structure of an airplane, including wing, fuselage, engine, tail surfaces, control systems, and landing gear. It was thereby possible to study the behavior of this "equivalent analogy" under various dynamic loadings such as vibration, landing shock, and gusts, and the stability of

the resultant aeroelastic system with respect to flutter oscillations.

Vibration forces are generated as currents by an audio-frequency oscillator. These are applied at various points and in combinations both to determine the natural modes of the structure and to measure the transmissibility with respect to sources of forced vibration within the aircraft.

Landing shock may be simulated in several ways, depending on the information available or required. The aircraft may be subjected to a force-time curve derived from laboratory or flight measurements or past experience. The energy of this reaction may be observed on the analogue computer and matched to its known value. Another method is to simulate the energy-absorbing characteristics of the strut and apply a landing impulse in terms of a vertical velocity change.

The aerodynamic forces on an oscillating airfoil are expressible in terms of a combination of Bessel functions. No simple analytic solution is known; however when the rigorous solution is graphed, it is discovered that it may be approximated by means of a one-half degree of freedom lag network. This allows the complete simulation of the aeroelastic airplane, and gust forcing functions may be applied. Flutter oscillation stability may be investigated either by transient or forced sinusoidal oscillation technique; however the transient appears to be the simplest and most practical at present.

Selection of Substation Transformers for Growing Loads; *R. E. Pierce, F. C. Poage (Ebasco Services Incorporated, New York, N. Y.).*

The most desirable or optimum responsibility of a substation serving a power distribution system in terms of load or of the area to be served, based on power loss economics, varies with physical and economic factors about as follows:

Directly as $^2/_3$ of distribution voltage
Directly as $^1/_3$ power of load density
Inversely as $^1/_3$ power of loss cost
Directly as $^2/_3$ power of site cost of substation
Inversely as $^1/_3$ power of (incremental) conductor cost
Directly as $^1/_3$ power of annual cost of money

The normal capability of transformers depends on the ambient temperature and daily load factor at the time of the maximum demand. Permissible emergency loads may be expressed in per cent of normal capability since the daily load factor, ambient temperature, and type of cooling are taken into account in finding the normal capability.

For a given total loss of transformer life caused by emergency loading the frequency and duration of emergency loads for different numbers of transformers sharing the load and the permissible emergency loads can be determined. For example, any one of the three transformers sharing load will have an overload when either of the other two is out, or say twice in 20 years. This corresponds to once in ten years, with say a ten per cent loss of life for each such emergency.

For a distribution area served by a number of substations with ties permitting some transfer of load, it may be more economical to operate all the transformers at something less than their capability and save losses, than have idle spare transformer capacity for emergencies.

The number of spare transformers needed does not vary directly with the number of transformers in service, but depends on the probability of multiple outages and the risk one is willing to take. Like all probabilities, the methods and figures developed indicate only the relative magnitude of the risks being taken.

A utility may well consider limiting purchases of transformers to standard sizes in size ratios of two to one with definite correlation between transformer size and substation switchgear ratings so that at some one definite step in the sizes the switchgear will be subject to near its rated duties.

Economics of Power Transformer Application; *J. E. Barkle, R. L. Witzke (Westinghouse Electric Corporation, East Pittsburgh, Pa.).*

Important economies can result from a proper selection of power transformers for generating stations and substations; however each application must be considered on its own merits. Conclusions reached relative to transformers for one location on a system may not apply on another system, or at another location on the same system.

The choice between single-phase and 3-phase transformers is influenced to a large extent by the need for spare capacity. When three single-phase units are used in a bank, it is possible to install a fourth unit at the same location as an emergency spare. This requires only 33-per cent additional investment to provide 100-per cent spare capacity, whereas 100-per cent additional cost would be required to install complete spare capacity with 3-phase units. However, transformers have a proved reliability higher than most other elements of a power system, and for this reason the need for immediately available complete spare capacity is often questionable. Three-phase units are quite generally used today with no on-the-spot spare transformer capacity. In these instances parallel or interconnected circuits of the system may provide emergency capacity, or, for small and medium-size transformers, portable substations can provide spare capacity on short notice.

At locations where grounded-neutral arresters can be applied close to the transformer, important savings can be realized by reducing the basic insulation level of transformers for systems operating at 115 kv and above. These applications require a complete engineering study to determine whether the reduced insulation can be adequately protected against surge voltages.

The installed cost of power transformers employing forced cooling may be appreciably lower than for self-cooled units having the same maximum, continuous kilovolt-ampere rating. The selection of the method of cooling, however, must give due consideration to other factors, such as capitalized cost of losses and reactive, emergency overload capacity, and reactance.

Multiphase Generators and Controls for High-Energy Particle Accelerators; *G. L. Godwin, L. A. Kilgore (Westinghouse Electric Corporation, East Pittsburgh, Pa.).*

The rapid strides being made in particle accelerator development demands high-voltage d-c power sources of ever-increasing rating. The proton synchrotron under construction at the University of California Radiation Laboratory requires 100,000-kw pulses of d-c power at 12,000 volts as often as ten times per minute. Accelerators requiring larger power supplies and high pulse rates are contemplated for the future.

Flywheel motor-generator sets are used in this application with high-voltage rectifiers so that the large block of energy stored in a proton synchrotron magnet at the end of the current build-up period can be recovered without large swings on the a-c system. The combination of a-c generators and rectifiers was chosen rather than d-c generators because a rapid reversal of direct voltage is desired to shorten the pulse and reduce the loss per cycle. The high peak load requires good voltage and speed regulation. To meet this requirement, a special low-reactance generator was required with a fast electronic exciter and regulator. To avoid the expense and the additional reactance of rectifier transformers, a special generator winding was developed suitable for carrying direct current. The short-circuit torque and pulsating load torques introduce some interesting torsional vibration problems.

The combination of high-voltage ignitron rectifiers fed directly from a specially designed flywheel motor-generator set gives an ideal power supply for the large magnets of the proton synchrotron type of particle accelerator.

Since the basic problems have been met and solved during the design of the initial units, it is expected that this general type of apparatus will probably find other applications in the future. Making use of the experience gained from these first power supplies, larger ratings can be built applicable to a wide range of pulsating rates.

Electric Drives for Paper Mill Supercalenders; *AIEE General Industry Application Committee Subcommittee on Pulp and Paper Industry.*

Marked improvements have been made in drives and controls for supercalenders during the past several years. Production speeds have risen from 500 feet per minute for line-shaft-driven machines with mechanical clutches to values of 2,500 feet per minute for machines powered by individual electric drives. The improvements have resulted from the need for higher rates of production, increased safety of operation, and higher quality of product.

An essential requirement for supercalender drives is a constant low-value threading speed with means for fast reliable acceleration and deceleration to and from the normal production speeds. The years of development since the line shaft have introduced variations of the following types of unit drives in order to attain this requirement.

1. A single-speed wound-rotor motor powered from a low-frequency and a normal-frequency power source.
2. Two suitable-speed squirrel-cage and wound-rotor motor units powered from a single frequency source, with over-running clutch to allow for the normal to threading speed difference.
3. A single d-c motor powered from fixed potential 250–125-volt busses with armature

resistance for threading and field control for maximum production speeds.

These older drives made use of manually operated mechanical friction brakes to maintain tension at the unwind stand and motorized manually operated slip-friction drives to maintain tension at the wind stand.

The latest supercalender drives are of the d-c variable-voltage and adjustable-speed type. A braking generator for the unwind stand and drive motor for the windup stand are arranged for operation in parallel with the main d-c motor for the stack. Sheet tension at both stands is maintained constant by rotating-type tension regulators. All units are powered from a d-c variable-voltage 3-unit motor-generator and control exciter set. The braking generator is operated as a motor to pay out paper to the supercalender during threading. Low-speed slack take-up, slow-speed inching, inertia controlled speed-up and slow-down are also features of the drive. An operator's control station at convenient location provides instruments, push buttons, rheostats, and signal lights for intelligent drive operation.

Theory of the No-Load Characteristics of Highly Saturable Reactors With Hysteresis; *Alfredo Banos, Jr.* (*University of California, Los Angeles, Calif.*).

Highly saturable materials like deltamax, orthonol, and so forth, have in common a very narrow hysteresis loop which rises almost vertically to a sudden and very flat saturation portion of the *B-H* characteristic. Neglecting hysteresis for the moment, the *B-H* characteristics of these materials may be closely approximated by straight line segments. In particular, if the rapidly rising portion of the *B-H* curve is assumed vertical, the magnetic properties of the idealized material can be characterized by means of only two parameters: the magnetic induction at the "knee" Bk and the incremental permeability μ_1 of the saturation portions. For this important case it is possible to plot the no-load characteristics of, say, a series-connected magnetic amplifier in the form of universal curves applicable to any particular situation. That is, introducing suitable physically dimensionless quantities which are respectively proportional to the volts per turn in the a-c circuit, the ampere-turns in the d-c or control circuit, and the rectified average a-c ampere-turns in the load circuit, one obtains curves applicable to any (idealized) material, any cross-sectional area for the toroidal cores, any mean length of magnetic path, and any frequency of the applied electromotive force. Furthermore, for this idealized case it is shown that the ampere-turn law of magnetic amplifiers holds exactly. This law states that, within a limited range of operation of the magnetic amplifier, the rectified average a-c ampere-turns in the load circuit equal the d-c ampere-turns in the control circuit. Finally, when one takes into account hysteresis, eddy currents, and distributed copper losses, it is shown that the ampere-turn holds only approximately and that the departures from the law, which are in the form of small corrections, can be readily computed in terms of additional parameters. The experimental characteristics as observed with a series-connected magnetic amplifier employing deltamax cores were translated into dimensionless quantities and the experimental points were plotted on top of the corresponding universal curves showing excellent agreement between theory and experiment.

This project was supported by the Naval Ordnance Test Station, Inyokern, Calif.

Applications of the National Bureau of Standards Western Automatic Computer; *H. D. Huskey* (*National Bureau of Standards, Washington, D. C.*).

The Institute for Numerical Analysis is a section of the National Applied Mathematics Laboratories of the National Bureau of Standards. It is located on the campus of the University of California at Los Angeles. The institute's primary purpose is to carry on research which will advance the art of computing and increase the utilization of automatic computing machinery. To do this effectively it is divided into three groups: the mathematical research, the computation, and the machine development units.

The mathematical research unit carries on basic research in numerical methods with the aim of determining optimum methods for solving problems on automatic digital computers. The computation unit operates to serve as a tool and proving ground for the research staff, with its services also being available for the use of other governmental agencies and governmental contractors. An automatic digital computer is being completed by the machine development unit, and on its completion will be a valuable addition to the institute. This machine is known as the National Bureau of Standards Western Automatic Computer (SWAC); it was financed by the Office of Air Research.

Heretofore the computing services of the computation unit have been based on a number of International Business Machines Corporation machines, including a card-programmed calculator (CPC), plus a small group of hand computers. The SWAC will undoubtedly greatly increase the scope of problems that can be efficiently handled by the institute as it has a much greater internal storage capacity and operates at a much higher speed than any of the present equipment. For instance, problems which would have taken approximately 20 years to solve previously could quite likely be solved in about a week on the SWAC.

It is too early to predict the trends in computing which will result from this new computing equipment. As previously mentioned, computing times will be reduced by factors between 100 and 1,000. In the beginning the time for preparing a problem will remain nearly the same. However, when standard routines for solving certain types of problems have been established this preparation, or coding, time should be lessened. What might be thought of as "libraries" of such routines will be established for insertion whenever necessary in a problem. Code words may be used to call into action these previously established and tested routines. Such a procedure may substantially decrease the preparation time for problems.

In the beginning the SWAC will be used for essentially the same type of problems as are now being handled at the institute. The research computing involves studies of matrix inversion, finding characteristic values of matrices, applications of Laguerre polynominals to network analysis, finding complex roots of algebraic equations, and so forth. The service computing covers the preparation of tables on rocket navigation, Bessel functions, Mathieu functions, and so forth, and the solution of such problems as the analysis of atmosphere diffusion, analysis of ram-jet data, flutter analysis, antenna problems, and trajectories.

A high-speed computer such as the SWAC can be used in logical operations as well as computing. For example, a project is underway whose purpose it is to study the possibilities of automatic substitution-translation, particularly in relation to the "translation" of foreign languages.

Subcommittee Report on Electric Equipment for Paper Mill Winders; *C. D. Beck* (*General Electric Company, Schenectady, N. Y.*).

Paper mill winders rewind the parent rolls from the paper machines, supercalenders, coaters, and so forth, into uniformly hard rolls with even edges which will permit smooth and rapid rewinding on subsequent processing machines. The winder itself consists of two drums which rewind the roll by driving on its surface. A separate unwinding stand is provided for the parent roll to be rewound. The winding drums are driven and the unwinding stand is equipped with a brake for applying back tension on the sheet.

Winder drives may be classified as "mechanical tension" or "regenerative tension" and are distinguished by the type of braking used on the unwinding stand. Regardless of the type of braking employed, the operating requirements of the winder drive remain unchanged and are

1. Smooth, rapid acceleration and deceleration, readily controlled.
2. A low bottom speed for threading a soft start, and usually provision for jog operation.
3. For some winders, means must be provided for adjusting the driving effort of each of the winding drums.

Where moderate paper processing speeds are used, the following types of mechanical tension drives and have found extensive use.

1. Wound-rotor induction-motor drive.
2. D-c constant potential drive.
3. Mechanical clutch drive.
4. Adjustable-speed (eddy current) clutch drive.
5. A-c adjustable-speed (brush shifting) motor drive.

For high-speed winders where the operating requirements are very exacting, the d-c adjustable-voltage (Ward Leonard) drive has become the accepted standard of the industry. The outstanding features of this type of drive are a low thread speed and controlled acceleration and deceleration Also, double motors can be used, one for driving each winder drum to provide additional control of the hardness or softness of the rewound roll, when required.

Regenerative tension drives employ a braking generator on the unwinding stand. An adjustable-voltage drive is always used on the winder drums. The braking generator is controlled to hold essentially constant sheet tension between the parent roll and the winder under all conditions of operation including, acceleration, deceleration, and as the parent roll size decreases.

Oklahoma City Will Be Host to Fall General Meeting in October

The AIEE Fall General Meeting for 1950 will be held in Oklahoma City, Okla., at the Skirvin Hotel from Monday, October 23, to Friday, October 27.

Arrangements are being made for a program of wide interest with several sessions on power generation, basic sciences, and communication. In addition, there will be a general session which is planned to interest a great many members. The tentative schedule of technical sessions for the meeting is as follows:

Monday, October 23

Transmission and distribution
Basic sciences
Television and carrier systems
Communication switching systems

Tuesday, October 24

General session
Transmission and distribution
Rotating machinery
Electronics

Wednesday, October 25

Insulated conductors
System engineering
Computing devices
Power generation
Industrial power systems

Thursday, October 26

Power generation
Relays
Cathodic protection
Switchgear
Mining and metal industries

Friday, October 27

Protective devices
Feedback control systems
Education
Transformers

PROPOSED INSPECTION TRIPS

The meeting also will afford an unusual opportunity to visit the various electrical installations in and around Oklahoma City. Five trips, as outlined in the following, have already been arranged for members and guests attending.

Trip 1. A tour of the Oklahoma City oil field and contiguous territory to show a drilling well in operation, natural gasoline plants, electric-power oil pumping stations, electrically pumped oil wells, and a general view of oil wells located on the State Capitol Building's grounds. The tour, which will cover 20 miles, will take about two hours.

Trip 2. A tour of the mechanical production plant of the Oklahoma Publishing Company (the printers of the *Daily Oklahoman* and *Times*) showing electrically operated and controlled presses, stereotype machinery, and wire photo service. This is one of the most modern newspaper publishing plants in the nation. Tour will take about $1^1/_2$ hours.

Trip 3. An inspection trip will be arranged covering the Arthur S. Huey Generating Station of the Oklahoma Gas and Electric Company. The feature interest at this station is the first commercial installation of a gas turbine unit applied to electric generation. This unit has been in service since July 1949, and has been phenomenally successful both as to dependability and performance. It has attracted international attention and will be seen in actual operation.

This tour will also include the Mustang Station which consists of two 50,000-kw steam turbogenerating units operating at 850 pounds per square inch at 900 degrees Fahrenheit. One of these units has been in operation since May 1950, and the second unit will be placed in operation about January 1951. This tour will consume approximately three hours and involve bus travel of about 25 miles.

Trip 4. This tour is to Tinker Air Base, the largest Air Force depot of the United States Department of Defense. Objects of interest will include the only jet engine overhaul assembly line in any of the Air Force depots; a close-hand view of the overhaul of the Number 3350 airplane engine used in *B-29*'s; and a close-up inspection of the *B-29* and the *B-36* (the 6-engine largest bomber of the Air Force). Also, a tour of the Commanding General's control room will be made and a lecture in the auditorium will be provided by the Commanding Officer, Major General F. S. Borum, on "What Goes On in an Air Depot." This activity employs more than 15,000 people and the electric load approximates 10,000 kw. The tour, by bus, will take approximately three hours and is scheduled to cover about 25 miles.

Trip 5. A tour through the downtown Oklahoma City Building of the Southwestern Bell Telephone Company will afford an opportunity for members to see in operation a large communication center. The inspection party will see the following: the terminal of the buried intercity long-distance cables from the east to south; facility for local exchange telephone service; equipment and switchboard for originating, terminating, and "through" long-distance telephone traffic; information and intercepting switchboards; facilities for providing and monitoring radio program network service; facilities for telegraph and leased wire service; a switching center for teletypewriter exchange service; facilities and switchboard positions for mobile radio-telephone service; a modern test center.

HOTEL ACCOMMODATIONS

Blocks of rooms have been set aside for attending members at six hotels in the business area of Oklahoma City and at one motor-hotel on the edge of the city. The Skirvin Hotel has been designated as headquarters for the meeting.

Reservations for rooms should be made early by completing the "Hotel Accommodation" card contained with the mailed announcement or by writing directly to R. L. Jones, 1101 Telephone Building, Oklahoma City 2, Okla., who is Chairman of the Hotel Committee.

Oklahoma State Capitol Building in Oklahoma City. In the foreground are the oil wells which are located on the Capitol grounds

Representative rates for hotel rooms are

Single room	$4.00–$ 6.00
Double room, double bed	6.00– 8.50
Double room, twin beds	6.50– 8.50
Suites	8.00– 25.00

All rooms are with bath.

Reservations are made for the night of October 22 and should be vacated by Friday evening, October 27.

COMMITTEE

The members of the 1950 Fall General Meeting Committee are as follows: W. B. Stephenson, Chairman; M. C. Reed, Secretary; R. F. Danner, Vice-Chairman; Frank Meyer, Vice-Chairman; Ralph Randall, Vice-Chairman; E. W. Allen, Publicity; Bryce Brady, Program; Mrs. R. F. Danner, Ladies; Otis Howard, Inspection Trips; R. L. Jones, Hotel; J. S. Joseph, Sports; George Larason, Entertainment; J. A. Taylor, Registration; J. S. Wantland, Finance.

Future AIEE Meetings

Middle Eastern District Meeting
Lord Baltimore Hotel, Baltimore, Md.
October 3–5, 1950
(*Final date for submitting papers—closed*)

Conference on Electrical Engineering in the Machine Tool Industry
Worcester, Mass.
October 11–13, 1950

AIEE/IRE Conference on Electronic Instrumentation in Nucleonics and Medicine
Park-Sheraton Hotel, New York, N. Y.
October 23–25, 1950

Fall General Meeting
Skirvin Hotel, Oklahoma City, Okla.
October 23–27, 1950
(*Final date for submitting papers—closed*)

Conference on High-Frequency Measurements
Hotel Statler, Washington, D. C.
January 10–12, 1951

Winter General Meeting
New York, N. Y.
January 22–26, 1951
(*Final date for submitting papers—October 24*)

Southern District Meeting
Miami, Fla.
April 11–13, 1951
(*Final date for submitting papers—January 11*)

North Eastern District Meeting
Syracuse, N. Y.
May 2–4, 1951
(*Final date for submitting papers—February 1*)

Great Lakes District Meeting
Madison, Wis.
May 17–19, 1951
(*Final date for submitting papers—February 16*)

Summer General Meeting
Royal York Hotel, Toronto, Ontario, Canada
June 25–29, 1951
(*Final date for submitting papers—March 27*)

Pacific General Meeting
Portland, Oreg.
August 20–23, 1951
(*Final date for submitting papers—May 21*)

Broad Summer and Pacific General Meeting Program Establishes Record Attendance

A broad technical program with sessions in each of the five divisions of Institute activity was presented at the combined Summer and Pacific General Meeting, which was held in Pasadena, Calif., June 12–16, 1950. The program was in keeping with the great industrial growth and large shift of population to the region of Southern California. More than 30 technical sessions and conferences were held during the five days, in addition to a number of important general business meetings such as the Annual Meeting; the Conference of Officers, Delegates, and Members; the Conference of Vice-Presidents and District Secretaries; the Board of Directors' meeting; and some 15 other committee meetings. The record attendance of 1,665 members, guests, and students testifies to the excellent arrangements made by the committees. Meeting headquarters and most of the entertainment were in the comfortable and spacious surroundings of the Huntington Hotel, while some of the extra sessions were held in the classrooms of the California Institute of Technology. Arrangements were made by the committee to take members to and from the sessions held outside the Huntington.

OPENING CEREMONIES

The meeting was opened by Fred Garrison, General Chairman, who explained that this was the fourth time that the Summer and Pacific Coast meetings had been combined. Section Delegates from the West Coast, Vice-Presidents, Directors, and officers were introduced.

An address of welcome was extended by R. W. Sorensen, Past-President of the AIEE, who has long been a resident of Pasadena. Doctor Sorensen referred to what engineers have done in Southern California and his comments embraced a period of time from 100 years ago, when the population was greatly exceeded by the number of cattle, up to the present. He touched on the early hydroelectric plants and the power transmission systems as well as the industries. Before World War II, he knew of two motor manufacturing plants and one small motor plant, whereas, now there are more than 50 plants that make motors, as well as 10 or 12 instrument shops, one of which made some of the first high-speed oscillographs. Industrialization of Southern California is progressing rapidly with large industrial centers that rival those east of the Mississippi River, and the region is growing twice as rapidly as any other place in the United States.

In the absence of municipal officials, Doctor Sorensen presented President Fairman with a key to the city.

ANNUAL MEETING

The Annual Meeting was held with President James F. Fairman presiding. First order of business was the presentation of the Report of the Board of Directors in abstract by Secretary H. H. Henline. In the presentation, Mr. Henline emphasized the extremely rapid rate of growth of the Institute which had a total membership on May 1 of 34,198, and in one month's time, by June 1, 1950, this figure reached 35,924. In the absence of the Treasurer, W. I. Slichter, Secretary Henline also presented a brief report of the Treasurer. A complete report of the Board of Directors, including the financial statements prepared by the auditors, appears on pages 738–64 of this issue.

The Report of the Committee of Tellers, which announced the election of the following AIEE officers, also was presented by Secretary Henline: for President, Titus G. LeClair; for Vice-Presidents, J. G. Tarboux, C. S. Purnell, J. R. North, H. R. Fritz, J. A. McDonald; for Directors, W. J. Barrett, A. G. Dewars, Victor Siegfried; for Treasurer, W. I. Slichter. President Fairman introduced the President-elect, T. G. LeClair, and presented him with the President's Badge. In response Mr. LeClair took a broad view of the problems ahead, both internal and external to the Institute. His remarks appear in full in the article "The President Looks Ahead" on page 667 of this issue.

To commemorate the 100th anniversary of the birth of Oliver Heaviside, the testimonial tribute was given by Dr. Paul S. Epstein, distinguished physicist, Professor of Theoretical Physics at the California Institute of Technology since 1921. Dr. Epstein, whose address gave the personal background and achievements of Oliver Heaviside, was introduced by President Fairman.

The Lamme Medal was presented to C. M. Laffoon, Manager of A-C Engineering Department, Westinghouse Electric Corporation, by President Fairman. The history of the medal was given by President Fairman and the career of the Medalist was outlined by A. W. Copley, retired Pacific Coast Engineering and Service Manager of the Westinghouse Electric Corporation. These addresses and the response of the Medalist are published in full on pages 670–72 of this issue.

At the conclusion of the meeting, a masterful address was presented by President Fairman on the question, "Is Engineering a Profession?" No one can afford to miss this important message which, if carried out to the spirit of the letter, would result in greater professional recognition, a rendering of more public service, and possibly the further development of unity of the whole profession so that the answer would be taken for granted. President Fairman's address appeared in full in *Electrical Engineering* for July (*pp* 579–82).

SECTION DELEGATES' CONFERENCE

The Section Delegates' Conference was held at the California Institute of Technology on Tuesday morning and afternoon with D. I. Anzini, Chairman of the Sections Committee, presiding and F. S. Benson, Secretary, recording. The Chairman stressed the fact that the meeting was to be informal and all delegates present were invited to take part in the discussions. Minutes of the Sections Committee meeting held during the Winter General Meeting in New York, were approved. Among the

topics discussed were the following: changes in Section territory, Section finances, membership and prize paper rules, publicity, registration of engineers, membership transfers, general business, recognition of Section Past-Chairmen, and proposed model bylaws for the Sections.

Remarks by Fairman and LeClair. President Fairman discussed some of the tasks of the office in relation to Section visits, the democratic processes by which the Institute should operate, and the nomination of officers. With the growth of the Institute and the various tasks of the office, he explained that it was no longer possible for the President to spend his time visiting the Sections except under the most extreme or extraordinary circumstances. While he had enjoyed the trips which were pleasant and interesting, belief was expressed that the Vice-Presidents were in much closer personal contact with their Sections and are in a better position to know their needs.

In regard to our democratic processes, President Fairman stated that the rank and file of the Institute needed an awakening on Institute affairs. The Board of Directors has been trying through membership opinion polls to guide Institute policies, but the results have not been too satisfactory. The first poll taken through the various Sections resulted in a 30-per cent return but there was much criticism that the issues were beclouded. The second poll with a return card which was published in the March issue of *Electrical Engineering* only produced approximately a 10-per cent return. With these efforts, administration could not be considered as autocratic when members are given an opportunity to express themselves and fail to do so.

In regard to the system for nominating officers and whether or not there should be two candidates for each office, President Fairman questioned whether such a scheme would be any better than that which is now in effect, which is highly selective and candidates are very carefully screened. He believes that the present method of electing Institute officers is the best way to do it and if the democratic processes are believed in and desired, the membership must work on it by beginning locally. Out of the effort will develop a stronger organization.

President-elect T. G. LeClair, speaking from long experience in Institute affairs, explained that some of the subjects under discussion were the same as those discussed many years ago, only that time and growth of the Institute has made these problems more difficult. Questions such as: "Shall we have local members or not?," "Shall we have local dues?," and so forth, must be solved by the ingenuity of each Section, though he regretted that it would not be possible to visit the Sections as there are three or four general meetings and two or three District meetings which the President should attend, and it is necessary for him to be present at the Board of Directors meetings. As the Board of Directors is the ruling body of the Institute, he believes there is no better way than to have the Vice-Presidents come to the meetings after they have visited some of the Sections, and then not only the officer at the head of the table would be informed, but also the entire Board of Directors. He urged that the Vice-Presidents be made welcome and in this way the Institute would get along better and attain results not obtained heretofore.

In regard to the matter of unity of the profession, he pointed out that we are all engineers first and specialists second. Where opportunities present themselves to hold joint meetings, this should be done. Prospective members should be imbued with the feeling that the engineering societies are becoming a unit by group.

Past-President Blake D. Hull addressed the gathering and endorsed the ideas of reducing the demands on the President to travel. Speaking from personal experience, he said that he found the duties of the office so arduous that it seemed to him that affairs at headquarters were being neglected while he was visiting the various Sections. He suggested that the Sections should carry their local and District problems to the Vice-Presidents and Directors of the respective Districts.

Changes in Section Territory. Regarding changes in Section territory, the Sacramento Subsection of the San Francisco Section, to include the counties of Sacramento, Placer, Sutter, Nevada, Eldorado, Yuba, Colusa, and Yolo, was recommended for full Section status. The recommendation was subsequently approved by the Board of Directors.

The recommendation was made that Park County, Wyo., be transferred from the Utah Section, some 600 miles away, to the Billings Subsection of the Montana Section, which is only 125 miles away.

In District 2, the committee recommended that Putnam County, Ohio, should be transferred from the Toledo Section to the Dayton Section. It was also recommended that Logan County in the Columbus Section be transferred to the Dayton Section.

The foregoing recommendations in regard to changes in Section territories were subsequently approved by the Board of Directors.

As there has been considerable confusion between the names Western Virginia Section and West Virginia Section, the motion was made that the name of the Western Virginia Section be changed to Blue Ridge Section of Virginia. Discussion suggested the simplification of the proposed name to "Blue Ridge Section," but an agreement could not be reached and the motion was set aside with the request that the West Virginia Section reconsider the simplification for the name of the proposed Section and seek approval at the time of the forthcoming Winter General Meeting.

Vice-President G. N. Pingree recommended that the Shreveport Section in Louisiana be transferred to the Texas territory. E. D. Nuttall of the Shreveport Section felt that the change was premature and suggested that the matter should be further discussed between the two Sections affected. General discussion took place on whether it was necessary to form a Subsection before Section status could be obtained. E. L. Holmgren and Chairman Anzini explained that it was only necessary to have a petition from 50 members residing in the area to form a Section.

Publicity. As R. K. Honaman, Chairman of the Public Relations Committee, was unable to be present, A. E. Knowlton of the Connecticut Section reviewed the subject of publicity. He stressed the fact that headquarters has been very active on this subject and that the Sections should become more active in publicity. It is important to win the confidence of the public and so the diligence of the electrical engineer in providing better living and working condi-

Electrical World photo

Attending the AIEE Summer and Pacific General Meeting in Pasadena, Calif., are seen, left to right: F. E. Andrews, Public Service Company of Northern Illinois; L. R. Jones, Leeds and Northrup Company; I. W. Gross, American Gas and Electric Company; S. B. Crary, General Electric Company; B. Cozzens, Department of Water and Power, Los Angeles; J. S. Carroll, Stanford University

Electrical World photos

(Left) R. W. Sorensen of the California Institute of Technology, Pasadena, presents the key to the city of Pasadena to J. F. Fairman, AIEE President for 1949–50, during the recent Summer and Pacific General Meeting in that city. (Right) Shown here attending the Summer and Pacific General Meeting are, left to right, AIEE Vice-President V. Siegfried, American Steel and Wire Company; AIEE Director W. L. Everitt, University of Illinois; and G. N. Pingree, General Electric Company

tions should be emphasized to the public at every opportunity. Mr. Knowlton also stated his belief that, in addition to publicity, the engineer must participate in civic affairs so that the public may understand the role of the engineer as an engineer and as a public official. Practically all of the Sections have Publicity Committees but only about half of the Sections use them. One Section delegate said that his Section's committee had been changed from Publicity Committee to Public Relations Committee, to give it a wider scope in dealing both with publicity and with the release of the engineer to public office.

J. D. Tebo of the New York Section stated that publicity is publicizing the meetings. It was suggested that the Public Relations Committee make news of the personalities of the individuals who operate the Sections, and that new Sections should have both a Publicity Committee Chairman and a Public Relations Committee Chairman on their Executive Committee.

Section Finances. The meeting was turned over to C. S. Purnell, who is on a Special Committee on Section Finances. He reported that at the Winter General Meeting in New York, it was indicated that the majority of Sections were living within their income. A brief report from 36 Sections indicated that the amount of money they were receiving was satisfactory and that budget requirements were met.

Discussion of several Section delegates indicated that the allotments they were receiving from headquarters were not sufficient to meet their needs. F. B. Krider of the Washington Section reported that they sent out 806 meeting publicity releases which cost approximately $1,000 a year. The Section resorts to special dues to meet the requirements. Other delegates pointed out that approximately 20 Sections were using joint bulletins with other engineering societies to announce their meetings. In the case of still another Section, the sending of meeting notices to students resulted in a saving of approximately $185. A canvass of the matter indicated that about half the Sections are sending notices to students. It was reported by E. L. Bettannier of the Los Angeles Section that a Section bulletin is issued together with five engineering societies which saves considerable money and permits them to obtain advertising from electrical industries.

A canvass of the meeting indicated that practically half the Sections have local members and do gain additional revenue from this source. Another canvass indicated that about two-thirds of the Sections publish a new roster yearly. This requires a considerable amount of money which reduces the funds available for other purposes.

The question was raised by W. S. Gordon, Jr., if it would not be possible for Sections to obtain additional funds if they held more than 30 meetings per year. A canvass of the situation indicated that 10–12 Sections have more than 30 meetings per year. Five Sections indicated that they have more than 40 meetings per year. A large number of meetings require a greater amount of money and some of the Sections indicated that approximately 75 per cent of the budget was for postage and publicity.

In conclusion, C. S. Purnell explained that headquarters realizes that the Sections have a financial problem and so is studying the matter. He complimented the Sections on exercising ingenuity in order to raise funds.

Membership and Prizes for Papers. The importance of the functions of the Sections Membership Committee, and particularly its chairman, was stressed by F. S. Black, Chairman of the Membership Committee. He stated that the large growth of the Institute was due entirely to the activities of the Membership Committees and that his committee was particularly pleased with the number of Student members as they are the nucleus for future Section members. He felt that every effort should be made to induce a graduate engineer to join the AIEE and that the chairmen must sell the Institute to the student and to the prospective member. He drew attention to a new membership folder which is available at headquarters; much information is offered, together with a cut-out postal card which requests the furnishing of additional information in regard to joining the Institute. In conclusion, he stated that the Section Chairmen should be very careful in selecting membership chairmen, who should be selected from the outstanding men in the Sections. In reference to the prizes for papers, F. S. Black drew attention to the awards available to the Sections and urged that every effort be made to induce members to write papers and compete for the national, District, and Section prizes. Discussion indicated that approximately ten Sections have prize paper contests each year. In response to an inquiry from J. M. Rodgers of the Dayton Section, it was explained that the cash award was considered to be a stimulating incentive to prepare papers and that the individual benefited greatly by writing a paper and the Section gained prestige. W. C. Smith of the San Francisco Section drew attention to the requirement that papers must be written. He suggested that the Sections should carefully review prize paper rules.

In conclusion, Mr. Black explained that the money for prizes for papers came from a separate fund at headquarters and that it is not taken out of the operating fund for the Sections. In addition to the cash award, a certificate would also be issued by headquarters to the winners of prizes.

Proposed Model Bylaws. Proposed model bylaws for Sections to be made available as guides were reviewed by W. C. Smith, Chairman of the special committee appointed to draw up the draft for these model bylaws. The final draft, which was presented to the meeting for discussion, was based upon copies of Section bylaws obtained from all over the country. At the conclusion of the review of the draft, during which a number of changes were proposed and approved, Mr. Smith stated that such approved changes would be made and that a revised set of model bylaws would be sent to delegates.

INSPECTION TRIPS

As always, a popular feature of the Summer and Pacific General Meeting was the schedule of inspection trips which, in this instance, was unusually long and diversified.

With an attendance of some 320 persons, probably the most popular of the inspections trips was that to the Mount Wilson Observatory and Television Stations on Wednesday evening. At the world-renowned observatory, visitors saw the 100-inch telescope and the Astrophysics Museum, as well as the other observatory features. Television facilities were inspected at the nearby Pacific

Telephone and Telegraph Terminal Station for the Mount Wilson–Hollywood Microwave Relay System, which transmits television programs from the Hollywood Central Office to Mount Wilson.

On Wednesday afternoon, a group of 80 visited Receiving Station E of the City of Los Angeles Department of Water and Power. This station is the dispatching station for the San Fernando Valley area and the terminus for one 287,000-volt transmission line from the Hoover Power Plant and the terminus for the 110-kv lines from the aqueduct plants 1 and 2.

Other trips which attracted a large attendance included tours of the Walt Disney Studios, the Fontana Works of the Kaiser Steel Corporation, *KFI-TV* Television Studios, and the Palomar Observatory.

ENTERTAINMENT

Social highlight of the Summer and Pacific General Meeting was the banquet which was held on Thursday evening around the Huntington Hotel pool. During the banquet, guests were entertained by personalities of the screen, radio, and television. The Presidents's Reception was held on Tuesday evening, preceded by an informal barbecue and Aquacade Show featuring stars of the American Olympic Team.

In addition to participation in the general entertainment events, the Ladies Entertainment Committee, under the leadership of Mrs. Fred Garrison, Chairman, and Mrs. H. L. Caldwell, Vice-Chairman, kept the visiting ladies occupied during the meeting with a garden tea, an audience participation television show, and tours of Hollywood and Beverly Hills.

SPORTS

The competition for the Mershon Golf Trophy was won by J. S. Antel of Washington, D. C., while the Fisken Cup was won by William O. Kyte, Los Angeles, Calif. Low scores were otained by the following: first flight, J. A. Tudor (low gross) and Homer Hussey (low net); second flight, A. H. Thayer (low gross) and W. F. Gronin (low net); third flight, C. R. Kingsbury (low gross) and Norman Holmdahl (low net). Blind bogey winners were J. H. Davis, S. Pardee, D. L. Rexford, Chet Schweers, A. W. Cartmell, and R. A. Young.

In the tennis competition, the Mershon Trophy was won by G. A. Palka, Los Angeles, Calif., with S. R. Durand, San Francisco, as runner-up. The doubles were won by G. A. Palka and Henry Oman, of Seattle, Wash.

COMMITTEE

Members of the General Committee, whose planning was largely responsible for the success of the meeting, included the following: Fred Garrison, Chairman, M. V. Eardley, Vice-Chairman; E. L. Bettannier, Secretary; E. S. Condon, Hotels; Bradley Cozzens, Finance; Mrs. Fred Garrison, Ladies; F. L. Goss, Entertainment and Program; G. T. Harness, Students; W. O. Kyte, Publicity; H. A. Lott, Technical Programs; E. W. Morris, Registration; H. F. Rempt, Arrangements; E. W. Rockwell, Transportation; G. F. Rucker, Inspection Trips; J. H. Vivian, Treasurer; H. S. Warren, Sports; R. A. Hopkins, Vice-President, District 8; N. B. Hinson, Director.

Summer Meeting Technical Sessions Cover Electrical and Electronic Subjects

The program of the technical sessions at the AIEE Summer and Pacific General Meeting in Pasadena was successfully designed to provide a wide coverage of electrical and electronic subjects. In the power field, sessions were devoted to transmission and distribution, transformers, hydroelectric systems, and applications to different industries such as lumber and paper mills, petroleum, and mining. Sessions dealing with computers, telephone switching, carrier currents, the Bevatron, magnetic amplifiers, and so forth, were well attended and the papers were received and discussed with enthusiasm. (Some of the conference papers will be found in abstract form on pages 717-26, and digests of some of the technical papers will be found in this and following issues of *Electrical Engineering.*)

ELECTRONICS

One application of electronic principles was explained in David Packard's paper, "Electronics Goes to the Farm," in which a photoelectric cell is arranged on tractor-drawn farming implements so that operations are performed only on healthy plants. This principle of optical discrimination has many possibilities in different types of devices employed on the farm.

This paper was the subject of a great deal of discussion in the session devoted to electronics on the first day of the meeting, over which W. H. Pickering presided. G. W. Downs and R. Morrison of the William Miller Corporation presented "An Oscillograph Amplifier Using a Transductor as the Input Stage" which is a circuit designed for maximum gain and in which no particular caution is needed concerning the contacts. Vernon Briggs, United States Naval Ordnance Test Station, read "A Simple Stabilized D-C Amplifier for Use With Electric Analogue Computers." These computers are used for the solution of differential equations which arise, for instance, in aircraft fire-control work. The features and characteristics of "Magnetic Modulators" was explained by Gunnar Wennerberg, Lear Inc., who was followed by M. J. Ainsworth, Bendix Aviation Corporation, with a paper, "Recent Trends in the Field of Miniature Electronic Components."

PARTICLE ACCELERATION

A session on particle acceleration and detection with A. M. Zarem of the United States Naval Ordnance Test Station as chairman contained an account of the "Operation of the 350-MEV Berkeley Synchrotron," by Marvin Martin of the University of California, as well as accounts of "Protron Linear Accelerators" by W. K. H. Panofsky of the University of California and "The Klystron as a High Power Source for the Electron Linear Accelerator" by Simon Sonkin of Stanford University.

Details of a 26-stage voltage doubler which provides "A 500-Kv Radio-Frequency Power Supply as a Bevatron Injector" were given by J. R. Woodyard of the University of California.

Carl D. Anderson, professor at the California Institute of Technology, winner of the Nobel Prize in physics for his experimental discovery of the positron, gave a paper on "Cloud Chamber Studies of Cosmic Rays." This was illustrated with slides of cloud-chamber photographs which gave a clear picture of the tangible evidence for many of the mystifying indivisible particles of modern physics.

TRANSFORMERS

The transformer sessions presided over by J. E. Clem, General Electric Company, were held on Wednesday, June 14. Papers and discussions were presented which can be divided into three groups.

One group dealt with transformer oil. A review of the facts obtained from studies of the oil were consolidated in the paper "Transformer Oil" by E. D. Treanor and E. L. Raab of the General Electric Company. "The Selection of Cooling and Oil Preservation for Power Transformers" was described by J. A. Elzi, Commonwealth Associates, Inc.

The second part of the program covered "General Considerations for Banking Distribution Transformers" by F. I. Nagle and N. K. Yarnell of the Southern California Edison Company.

The third, and largest, group concerned the selection, application, design, and operation of power transformers both from the users' and manufacturers' points of view. "Selection, Application, and Operation of Large Power Transformers on Southern California Edison Company System" was described by C. L. Sidway and L. H. Beebe of that company. An analysis of methods to be used to reduce first and long-term transformer costs, as well as the reliability of these methods, were covered by Charles M. Short, of the Department of Water and Power, City of Los Angeles, and W. G. Hart of the General Electric Company, in their paper, "Engineering and Economic Considerations Applicable to Large Power Transformer Installations." The surveys and studies leading to the adoption of the values for voltage ratings and taps of power and distribution transformers given in the Edison Electric Institute–National Electrical Manufacturers Association Report on Preferred Voltage Ratings for A-C Systems and Equipment were described by H. P. St. Clair of the American Gas and Electric Service Corporation, and H. M. Jalonack, General Electric Company, in the paper "Development of Preferred Voltage Ratings for Transformers."

In the afternoon session on transformers the philosophy underlying power transformer practices in their company were discussed by F. A. Lane, I. W. Gross, and P. S. Pugh in their paper "Selection, Design, and Operation of Power Transformers on American Gas and Electric Company System." "Selection and Application of Power Transformers" by H. P. Seelye of the Detroit Edison Company showed the relation between the needs of the operating system and some of the standardization activities in progress in the company and in the industry. An approach to evaluate the factors affecting the selection of transformers was presented by N. E. Dillow and J. W. Butler of the General

Electric Company in "The Choice of Main Power Transformers for Generating Stations." Two conference papers were presented at this session. They were: "Selection of Substation Transformers for Growing Loads" by R. C. Pierce and F. C. Poage, Ebasco Services, Inc., and "Economics of Power Transformer Application" by J. E. Barkle and R. L. Witzke, Westinghouse Electric Corporation. Two papers were presented by title only; they were "Transformer Sound-Level Considerations" by A. J. Maslin of the Westinghouse Electric Corporation, and "Quiet Transformer Installations—A Problem for Both Equipmnt and Substation Designers" by I. S. Mendenhall and F. L. Taylor of the Detroit Edison Company.

MICROWAVES

The microwave session on Thursday, June 15, presided over by S. C. Leyland of the Westinghouse Electric Corporation, included three published technical papers and two conference papers. An experimental installation of a microwave channel was described in "Field Testing a Microwave Channel for Voice Communication, Relaying, Telemetering, and Supervisory Control" by D. R. Pattison of the Pennsylvania Electric Company, M. E. Reagan, S. C. Leyland, and F. B. Gunter, all of the Westinghouse Electric Corporation. "Microwave Applications to Bonneville Power Administration System" were described by R. F. Stevens and T. W. Stringfield of the Bonneville Power Administration. The advantage of using microwave equipment for the transmission of intelligence in the operation of a power system were covered in "Microwave Systems for 960 and 2,000 Megacycles" by R. V. Rector of the General Electric Company and W. E. Sutter of the International General Electric Company.

Conference papers presented at this session were "940- to 960-Megacycle Communication Equipment for Industrial Applications," F. B. Bunter, Westinghouse Electric Corporation, and "Problems to Be Solved in the Application of Microwave Equipment," R. C. Cheek, Westinghouse Electric Corporation.

Discussion of the papers indicated an extensive interest in microwave services for power system communication and control, particularly where multiple services are required over difficult terrain. There was considerable discussion of various and additional means of channelizing for microwave installations with the result that future engineering data will be helpful in increasing confidence in this type of communication service.

CARRIER CURRENT

Thursday afternoon, June 15, the Conference on Carrier Current was led by R. H. Miller of the Pacific Gas and Electric Company. The first paper, "A Low Noise and Distortion Audio Multiplexing Equipment With High-Stability Carrier Supply," was presented by F. S. Beale of the Westinghouse Electric Corporation. The equipment described in the paper was the result of conclusions reached while studying the problem of utilizing the 30-kc spectrum offered by type-*FB* microwave radio equipment. Conference papers presented were "Integrated Power Line Carrier System" by H. S. Lane, Pacific Gas and Electric Company, "Measurements and Tests on Power Line Relaying System," R. H. Miller, Pacific Gas and Electric Company, and "Methods of Trap Tuning," C. R. Canady, Southern California Edison Company. The technical paper, "Modern Carrier Current Test Equipment and Its Application," by R. L. Brinton of the Pacific Gas and Electric Company was presented by title only.

A discussion of the papers indicated the need for additional means of carrier current channelizing, similar to microwave applications, and improved automatic equipment for general communication and associated control services. It was brought out that the problem of frequency congestion in the 50 to 250-kc band is of concern to those power organizations employing extensive use of carrier-current channels and will be of increasing importance as power-line carrier installations are applied to interconnected power systems. Proposals were recommended for improved broad-band tuning of carrier line traps to provide additional channels and more flexible adjustments.

INSTRUMENTS AND MEASUREMENTS

On June 15, six papers were presented at a session on instruments and measurements, which was presided over by W. R. Clark, Beacon Electric Company, Philadelphia, Pa.

"Principles of Design of Log-Scale D-C Indicating Instruments" by Allen Stimson and C. F. Taylor, General Electric Company, was presented by Mr. Stimson. Instruments which use logarithmic-scale distribution provide equal per cent reading accuracy over the entire scale range and give high sensitivity at the low end of the scale as well as a large scale range. Its use as an exposure meter has proved successful. The magnetic system must be designed in accordance with the point-by-point method.

"Output Analysis and Alignment Techniques for Phase-Rotation Single Sideband Transmitters" by Oliver Whilby and D. R. Scheuch, Stanford Research Institute, was presented by Mr. Whilby. Systems may become unbalanced and produce unwanted sidebands. Through the use of the transmitter alignment indicator, an analysis of the output is made and any misalignment can be easily detected.

A paper entitled "Electrical Measurement of Microsecond-Duration Dynamic Strains" was given by L. A. Roberts, Palo Alto, Calif. This method of making measurements has certain advantages over the former photography methods. A resistance strain gauge is used, and it is only necessary to calibrate the signal by comparison.

W. G. Hoover, Stanford University, discussed "Operation of Electrodynamometer Instruments Through Amplifiers." Voltage, current, and small power measurements can be made with great accuracy by this method of connecting an electrodynamometer type of instrument to an amplifier. A high-gain amplifier is used, and the amplification is then reduced by using a large amount of feedback. A flat response up to 5,000 cycles can be obtained.

"Use of High-Pressure Mercury-Arc Lamps for Pulsed Light Applications" by R. O. Briggs, F. W. Looschen, and S. F. Schmidt, Ames Aeronautical Laboratory, was presented by Mr. Schmidt. High-pressure mercury lamps are especially adaptable to certain types of aeronautical research and can be used as a continuous light source or as a pulsed light source to obtain pulse durations as short as 0.2 microsecond. The air-cooled *BH-6* lamp is now in use, and two higher-intensity lamps have recently been designed.

W. D. Hershberger, University of California, presented the paper, "Present Status and Applications of Microwave Spectroscopy." Microwave spectroscopy uses techniques borrowed from radar and is valuable in the study of molecular structure and chemical identification. Very minute quantities can be detected; one hundredth of any amount of any material can be detected by this method over other methods. The 1.25-centimeter range is the most popular frequency.

TRANSMISSION AND DISTRIBUTION

The morning session on transmission and distribution on June 13 was presided over by I. W. Gross, American Gas and Electric Service Corporation. The first paper by Philip Sporn, American Gas and Electric Service Corporation, and A. C. Monteith, Westinghouse Electric Corporation, was a progress report on the Tidd 500-kv test project. (*EE, July '50, pp 506–11*). This was followed by "Desert Measurements of Corona Loss on Conductors for Operation Above 230 Kv" by W. S. Peterson and B. Cozzens, Department of Water and Power, Los Angeles, Calif., and J. S. Carroll, Stanford University. This was a report of the findings of the 13-year test on the Boulder Transmission Line. In the paper "Long-Distance Power Transmission" by S. B. Crary, General Electric Company, Schenectady, N. Y., the results were presented of recent studies for determining the performance characteristics of long-distance transmission systems, the analysis being directed toward a consideration of straightaway systems of 600 miles in length.

F. E. Andrews, M. A. Andersson, and L. R. Janes, Public Service Company of Northern Illinois, presented "Interrupting Ability of Horn-Gap Switches." This paper reported the findings of an investigation with the following objectives: the study of arc behavior on horn-gap switches under various system conditions; the determination of the magnitude of currents which can be interrupted on existing switches under prevailing system conditions; and to determine basic switch design factors for successful operation under specified conditions.

The afternoon session, over which J. T. Lusignan, Jr., Ohio Brass Company, presided, included relays with transmission and distribution papers. The first paper was by T. M. Blakeslee and E. L. Kanouse, Department of Water and Power, City of Los Angeles, "Thirteen-Year Lightning Performance of Boulder 287.5-Kv Transmission Lines" (see pages 706–08 of this issue). The second paper was by the Lightning and Insulator Subcommittee on "Methods of Estimating the Lightning Performance of Transmission Lines." In the discussion following these two papers, Professor E. C. Starr warned about the use of the coupling factor as affected by corona. P. L. Bellaschi emphasized the need for considering longer front lightning surges than had been assumed in the past.

The next paper, "The Bonneville Power Administration Relaying and Reclosing Program" by C. C. Diemond and D. L. Wylie, Bonneville Power Administration, described the steps being taken to correct some of the weaknesses in protective relaying

experienced on the 230-kv transmission line. System performance was studied on the Bonneville Power Administration a-c network analyzer for anticipated operating conditions and for actual system breakups which were initiated by simultaneous 230-kv multicircuit outages during lightning storms. The studies disclosed that automatic reclosing at high speed would be of benefit in maintaining stability, especially during multicircuit outages. These reviews also established the necessity for replacing the distance relays with modified impedance units and for improving the performance of the carrier relaying.

The final paper of the session was presented by W. A. Morgan and R. W. World, Bureau of Reclamation, Denver, Colo., "Relaying Practices and Economical Switching Station Arrangements of the Bureau of Reclamation." This paper described some of the relaying schemes used by the Bureau in the western part of the United States on high-voltage transmission systems which are characterized by longer line sections between substations than is common in the eastern half of the country where the population density is greater.

In the discussion following, S. C. Leyland pointed out the desirability of out-of-step blocking and that electronic relays are not free from all the troubles of mechanical relays. Dr. E. L. Harder brought out that 20-cycle reclosure times might involve difficulties during multiple strokes.

HYDROELECTRIC SYSTEMS

A session on hydroelectric systems was held on June 16 with G. R. Woodman of the Southern California Edison Company presiding.

A recently developed hydroelectric project in British Columbia, Canada, described in a paper, "The Bridge River Hydroelectric Development" by T. Ingeldow and J. H. Steede, British Columbia Electric Railway Company, Ltd., was presented by H. W. Smith of the British Columbia Electric Railway Company, Ltd. Three of the ten 62,000-horsepower units in this project, which is being developed to furnish power to the Vancouver area, are in operation at present. Its natural setting accounts for the unusual design; a 13,200-foot tunnel carries the water from the intakes above the dam in the Bridge River to the penstocks supplying the large verticle impulse turbines in the powerhouse located on an entirely separate body of water. The generators are 50,000-kva 300-rpm 60-cycle units.

A paper entitled "Underground Hydroelectric Power Plants" by P. E. Gisiger, Sao Paulo Tramway Light and Power Company, Sao Paulo, Brazil, was presented by T. B. Staber, Washington, D. C. Underground hydroelectric power plants had been built and operated years before the war so that protection during war times was not the foremost reason for their design. Such plants are favored in countries as Sweden, Switzerland, France, and Italy for technical and economical reasons as, for instance, in case of foundation difficulties or severe climatic conditions which prevent all year round construction above ground. In addition, Mr. Staber pointed out that underground plants have been used to advantage in this country in the past and that sites were being considered for similar projects in the future.

"Underground Hydroelectric Power Stations in Sweden" by Åke Rusck and G. Westerberg, Swedish State Power Board, was presented by W. C. Merritt, Pacific Gas and Electric Company. Water power resources in Sweden are capable of producing 50,000 million kilowatt-hours per year; 30 per cent of this amount is now being produced. Underground stations are considered usually on the basis of economic reasons. Problems of maintenance, drainage, ventilation, and heating in such stations have not been considered difficult. Slides showing completed stations and stations under construction were shown.

ELECTRONIC POWER CONVERTERS

On June 16 a session on electronic power converters was held with C. C. Herskind, General Electric Company, and H. H. Cox, Water and Power Department, City of Los Angeles, presiding.

S. R. Durand, Allis-Chalmers Manufacturing Company, presented a paper entitled "High-Voltage Rectifier Equipment and Control for Tube Testing." Mercury-arc rectifier equipment rated at 2,000 kw, which provides the great flexibility required for the testing of high-power radio transmitting tubes, has been designed. Slides giving a schematic diagram of the equipment, as well as the overload protective circuit and phase control circuit, were shown and explained.

Two high-voltage rectifiers using newly designed sealed ignitron tubes, as described in a paper entitled "High-Voltage Ignitron Rectifiers" by M. J. Mulhern, General Electric Company, were discussed by C. C. Herskind. One uses a 50-ampere tube and is capable of delivering 17,000 volts at a load of 2,500 kw, and the other uses a 150-ampere tube and can deliver 17,000 volts at a load of 7,500 kw. Slides of the tubes, of the rectifier circuit, and of the location of the tubes in the equipment were shown.

"Ignitron Pulse Equipment for Particle Accelerators" by C. C. Herskind and J. E. Hudson, General Electric Company, was presented by Mr. Herskind. Ignitron tubes using mercury-pool cathodes are now used in the power circuits of particle accelerators to provide high-current pulses of short duration. Pulses of 5 to 30 kiloamperes of 0.01 second are required for producing the magnetic field in some accelerators. Both the sealed and pumped ignitrons have been used successfully in the circuits.

Waldo Porter, Aluminum Company of America, presented a report of the Application Subcommittee of the AIEE Committee on Electronic Power Circuits, "Survey of Operation of Mercury-Arc Rectifiers." Information was obtained from 656 users of mercury-arc rectifiers of which approximately 80 per cent were in the mining, steel, and general industrial classification, and 10 per cent each in the electrochemical service and railway transportation service. Details regarding the total capacity and various types used by each group, components which most frequently cause outages, tube life, and arc-back were discussed.

"A Brief Pictorial Story on the Early Development of the Mercury-Arc Rectifier" was given by W. C. White, General Electric Company. Early progress on this tube extended from the year 1860, when the mercury arc was first demonstrated in London, England, until the beginning of the 20th century, when Hewitt announced his mercury-arc lamp and mercury-arc rectifier. Later tubes were designed to produce high-voltage direct current for street lighting and electric traction. In 1914 controlling the arc by means of a grid was introduced, which led to the later development of the thyratron, in 1928, and the sealed-off steel-envelope ignitron, in 1934.

Middle Eastern District Meeting Scheduled for Baltimore, Md.

Baltimore, Md., will be host this year to the AIEE Middle Eastern District Meeting which will be held at the Lord Baltimore Hotel, October 3–5, 1950. The various committees have been organized by the respective chairmen and plans for the meeting are rapidly nearing completion. An outstanding program is being arranged to include a fine array of technical meetings and papers, while inspection trips of sufficient diversity to interest every member and guest

Members of the General Committee which is engaged in making plans for the AIEE Middle Eastern District Meeting to be held in Baltimore in October are, seated (left to right): Charles Wallace, C. R. Durling, Mrs. J. L. Hildebrandt, T. E. Marburger (Chairman), Dr. P. L. Betz, G. R. Page, M. C. Albrittain. Standing (left to right) are: J. Q. Wray, F. E. Winslow, L. G. Smith, A. A. Zimmar, C. S. Fiske, J. B. Homsher, T. H. Marshall, Jr., and R. W. Watters. Absent from this group are committee members Donald Gunn, W. C. Wilkinson, and Eduard Fritz

are also on the agenda. In addition to the serious aspects of the meeting, arrangements are being made for an oyster roast in the traditional Maryland manner, a gala dance for members, guests, and their ladies, and sports events to suit a wide variety of tastes.

Activities exclusively for the ladies are to include a visit to and tea at McCormick and Company, the world's largest spice processor, cocktails, dinner with music, a fashion show, cards and games and a trip to Annapolis, Maryland's capital, when the ladies will visit various historical homes and buildings, lunch at famed Carvel Hall, inspect the United States Naval Academy, and attend a reception at the Governor's Mansion.

The following committee chairmen have been appointed by Thomas E. Marburger, Chairman, General Committee: G. Russell Page, Arrangements; L. G. Smith, Students; Paul L. Betz, Technical Meetings; Thomas W. Trice, Special Meetings; M. C. Albrittain, Finance; T. H. Marshall, Jr., Publicity; Donald Gunn, Smoker; W. C. Wilkinson, Sports; Charles Wallace, Entertainment; C. R. Durling, Dinner-Dance; Eduard Fritz, Registration; C. S. Fiske, Inspection Trips; Mrs. J. Lawrence Hildebrandt, Ladies.

AIEE Plans Sessions at Annual Meeting of ISA

The Instruments and Measurements Committee of the AIEE is planning two technical sessions for the fifth annual meeting of the Instrument Society of America to be held at the Memorial Auditorium in Buffalo, N. Y., September 18–22, 1950. Present plans indicate that the sessions will be held on Wednesday, September 20, and Thursday, September 21; one will be devoted specifically to electronic instruments while the other will consist of papers on the general subject of electric instruments and measurements.

In addition to the two AIEE sessions, there will be a joint luncheon and technical meeting with The American Society of Mechanical Engineers, sponsored by the Industrial Instruments and Regulators Division of the ASME. Papers of interest to AIEE members will include: "Compressibility Effects on Servomechanisms," "Electric Contacts for Instruments," and "The Vector Meter."

Local arrangements for the AIEE part of the fifth National Instrument Exhibit are being handled by the following Niagara Frontier Section members: J. J. Bowen, Chairman for local arrangements; R. S. Forbes, Jr., who will handle AIEE publicity in the area; Douglas J. Munhall, in charge of reservations and hospitality; and Burton S. Rice, Chairman-elect for the Section, who will be responsible for providing personnel to take care of the AIEE booth.

Domestic Appliances Subject of Conference in Cleveland

Automatic washing machines and electric ranges were highlighted at a very successful Conference on Domestic Appliances held in Cleveland, Ohio, on June 20, 1950. The conference was conducted by a special subcommittee of the AIEE Committee on Domestic and Commercial Applications and sponsored by the AIEE Cleveland Section. Because of the enthusiasm of those attending, the committee is planning to promote such a conference next year as part of its activity.

The first speaker, P. E. Geldhof, Whirlpool Corporation, expressed the manufacturer's viewpoint that more efficient automatic washers could be marketed at lower prices if better and cheaper parts could be obtained, while David Hays, American Home Laundry Manufacturers Association, pointed out that the achievement of balance in the assemblies of machines constituted the number 1 engineering job needed by automatic washer manufacturers. "Appliance Design and Utility Growth" was the subject of another speaker, R. C. Hienton, Cleveland Electric Illuminating Company.

The General Committee and speakers for the recent Cleveland Conference on Domestic Appliances included the following. Front row, left to right: P. E. Geldhof, Whirlpool Corporation; E. N. Calhoun, Edwin L. Wiegand Company; Mr. McNiece, who substituted for W. R. Milby, Detroit Edison Company; T. H. Cline, Newark Stove Company. Second row: R. F. Zimmerman, General Motors Corporation; J. R. Wickey, Clark Controller Corporation; R. S. Gardner, AIEE; R. C. Hienton, Cleveland Electric Illuminating Company; C. R. Reid, The Hoover Company. Third row: R. L. Oetting, General Electric Company; T. H. Davis, Jr., Hotpoint, Inc.; W. T. Clark, Cleveland Electric Illuminating Company; C. F. Scott, General Electric Company

AIEE Richland Section Holds Meeting

On June 23, 1950, the AIEE Richland (Wash.) Section held a dinner-meeting which featured addresses by David F. Shaw, on "Synchronization of Engineering," and AIEE President Titus G. LeClair, who discussed the question, "Where Is the Engineering Profession Going?" Shown here at the speakers' table are, left to right: F. J. Mollerus, General Electric Company, Chairman-elect of the Richland Section (currently Vice-Chairman), who presided at the meeting; Mr. Shaw, manager of the Hanford Operations Office of the Atomic Energy Commission; Mr. LeClair, who is with the Commonwealth Edison Company, Chicago, Ill.; F. K. McCune, General Electric Company; R. B. Crow, Atomic Energy Commission Hanford Operations Office, Vice-Chairman-elect of the Richland Section (currently Secretary-Treasurer); R. W. Stuck, Atomic Energy Commission Hanford Operations Office

New Jersey Division Holds Spring Meeting

The New Jersey Division of the AIEE New York Section held its annual spring meeting on Friday, May 26, 1950, at the new Johns-Manville Research Center in Manville, N. J. The meeting included a conducted tour of the Research Center, dinner, and an evening program of entertainment.

The Division had as its guests AIEE President T. G. LeClair and Past-President J. F. Fairman, both of whom addressed the meeting. Mr. LeClair, in his talk, stressed the determination of the AIEE to remain alert to meet trends as they develop.

1951 Pacific General Meeting Committee. According to a recent announcement, the following have been appointed members of the general committee to make plans for the Pacific General Meeting which is to be held in Portland, Oreg., during the week beginning August 20, 1951: C. B. Carpenter, Chairman; M. M. Ewell, Vice-Chairman; W. Morgan Allen, Secretary; A. O. Mangold, Treasurer. The subcommittee chairmen will be: A. O. Mangold, Finance; Waldo E. Enns, Technical Program; Delmar L. Brown, Registration; Cecil L. Brown, Hotel; M. D. Duffy, Entertainment; O. A. Demuth, Inspection Trip; R. B. Temple, Student Activities; J. H. Burrus, Transportation; R. R. Bracchi, Publicity; Waldo Porter, Sports.

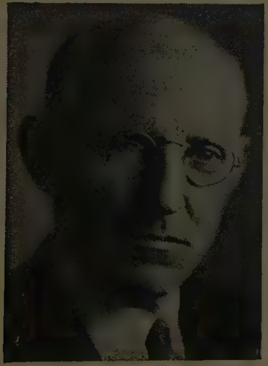
COMMITTEE ACTIVITIES

Editor's Note: This department has been created for the convenience of the various AIEE technical committees and will include brief news reports of committee activities. Items for this department, which should be as short as possible, should be forwarded to R. S. Gardner at AIEE Headquarters, 33 West 39th Street, New York 18, N. Y.

Note. Because of the changeover in committee personnel, no items on committee activities are included in this issue.

AIEE PERSONALITIES.....

R. E. Doherty (A '16, F '39), President, Carnegie Institute of Technology, Pittsburgh, Pa, has retired. Dr. Doherty was born in Clay City, Ill., on January 22, 1885, and received a Bachelor of Science degree from the University of Illinois in 1909. In 1921 he received a Master of Science degree from Union College and in successive years he received the following honorary degrees: Master of Arts, Yale University, 1931; Doctor of Laws, Tufts College, 1936; Doctor of Laws, University of Pittsburgh, 1936; and Doctor of Science, Waynesburg College, 1948. From 1909 to 1931, Dr. Doherty worked for the General Electric Company, Schenectady N. Y., where he served for six years as assistant to Dr. Steinmetz. At General Electric he was consulting engineer and, also, headed the company's educational program. In 1931, Dr. Doherty left General Electric to join the Yale University faculty as Professor and Chairman of the Department of Electrical Engineering. Two years later he was made Dean of the Yale School of Engineering. He became President of Carnegie Institute of Technology in 1936. In 1937, Dr. Doherty was awarded the AIEE Lamme Medal for his work on electrical machinery and, in 1946, he was presented with the Lamme Medal of the American Society for Engineering Education. Dr. Doherty has had many papers published in scientific journals and has taken an active part in professional societies. He is a past chairman of the Engineers Council for Professional Development, and a past president of the Society for the Promotion of Engineering Education (now the American Society for Engineering Education). Dr. Doherty has served the Institute as a member of the following committees: Education (1918–19, 1926–28, 1931–35, 1939–41, Chairman 1931–33); Electrophysics (1924–26); Power Transmission and Distribution (1928–29); Technical Program (1931–33); and Edison Medal (1941–46, Chairman 1946). He is also a member of Sigma Xi, Tau Beta Pi, Eta Kappa Nu, and a fellow of The American Society of Mechanical Engineers.



R. E. Doherty

R. C. Sprague (M '40, F '49), President, Sprague Electric Company, North Adams, Mass., has been elected President and Chairman of the Board of Directors of The Radio-Television Manufacturers Association. The Radio-Television Manufacturers Association is the new name of Radio Manufacturers Association which becomes effective when the corporate charter amendment is approved by the Secretary of the State of Illinois. Mr. Sprague has been a Director of Radio Manufacturers Association since 1943 and was chairman of the RMA Parts Division for two terms, 1944–45 and 1945–46. More recently he has been chairman of the RMA "Town Meetings" Committee which directed numerous activities in the interest of radio and television dealers and service technicians. Born August 3, 1900, in New York, N. Y., Mr. Sprague was educated at the United States Naval Academy, the United States Naval Post-Graduate School, and the Massachusetts Institute of Technology. He founded the Sprague Electric Company (originally the Sprague Specialties Company) in 1926. During and immediately after the war, Mr. Sprague was a member of the War Production Board Advisory Committee on Electric Condensers (1942–45), and Chairman of the Office of Price Administration Industry Advisory Committee for the Radio Parts Industry (1944).

E. A. Walker (A '34, F '47), Head of the Electrical Engineering Department and Director of the Ordnance Research Laboratory, Pennsylvania State College, State College, Pa., is the new Executive Secretary of the Research and Development Board. Dr. Walker has been associated with the Board during the past year as a consultant to its Committee on Electronics. Dr. Walker recently took leave of absence from Pennsylvania State College to serve as deputy chairman of a weapons panel in the National Research Council. He was just recently elected a Director of the Engineering College Research Council. During World War II he was assistant director of the Underwater Sound Laboratory at Harvard University and served with the Office of Scientific Research and Development. From 1940 to 1942 he was head of the Electrical Engineering Department at the University of Connecticut and served in the same capacity at Tufts College from 1934 to 1940. Dr. Walker is serving the Institute as a member of the Committee on Education and the Research Committee. He is a fellow of the Acoustical Society of America and the American Physical Society and is a member of the American Society for Engineering Education, Institute of Radio Engineers, American Institute of Physics, and the American Philatelic Society.

E. S. Pillsbury (M '19), President and Managing Director, Century Electric Company, St. Louis, Mo., has retired from the presidency of the company but will continue as Chairman of the Board of Directors. Mr. Pillsbury has been President of the company since 1914. He was born on January 12, 1867, in Manhattan, Kans., and attended Massachusetts Institute of Technology. He was associated with various electrical concerns as a design engineer prior to joining the Century Electric Company in 1902. **F. H. Pillsbury** (A '49), Vice-President in charge of operations and a member of the Board of Directors, will succeed his father as president of the company. The new president joined the company in 1927 following his graduation from Washington University. He was named a member of the Board of Directors in 1942 and vice-president in charge of operations in 1949.

K. W. Graybill (M '38, F '45), Chief Engineer, Automatic Electric Company, Chicago, Ill., has been elected Vice-President of the company. Mr. Graybill will also remain in the capacity of Chief Engineer. He has been with the company since 1920, when he was first assigned to the engineering inspection department. Mr. Graybill took charge of this department in 1927 and, in 1934, he was transferred to the Automatic Electric Laboratories, of which he became president in 1936. Continuing in this capacity Mr. Graybill became, in addition, chief engineer of the company in 1938. He is a

member of the Western Society of Engineers, American Society for Metals, American Society for Testing Materials, and the American Association for the Advancement of Science.

G. R. Anderson (A '22, M '29), Director of Engineering, Fairbanks, Morse and Company, Chicago, Ill., has been appointed General Manager of the Freeport (Ill.) Works of the company. Mr. Anderson is a graduate of the Electrical Engineering School of the University of Michigan. He joined Fairbanks, Morse and Company at their Indianapolis (Ind.) Electric Works in 1922. He was transferred to the company's Beloit Works in 1929, and was appointed Chief Electrical Engineer in 1932 and Manager of Engineering in 1946.

W. C. Broekhuysen, (A '23, M '44), Project Executive, Electrical Engineering Department, American Machine and Foundry Company, Brooklyn, N. Y., has opened an independent engineering office at 28 Hollywood Plaza, East Orange, N. J. The major part of his activities will be directed toward the development of electric controls for manufacture by G-V Controls, Inc., at the same address, of which he becomes Chief Engineer. Some time will also be devoted to electrical and mechanical engineering work for other concerns.

R. H. Olson (A '21, M '47), Vice-President in charge of sales, Electric Machinery Manufacturing Company, Minneapolis, Minn., has been elected President of the company. **A. P. Burris** (M '44), Manager, New York Sales District, succeeds Mr. Olson as Vice-President in charge of sales. Mr. Olson and Mr. Burris are both graduates in electrical engineering from the University of Minnesota. Mr. Olson joined the company in 1919 and Mr. Burris became associated with the company in 1930.

S. M. Sharp (A '26, F'48), Chief Engineer, Southwestern Gas and Electric Company, Shreveport, La., has been named Vice-President of the company. He will remain in the capacity of Chief Engineer. Mr. Sharp is a graduate of the University of Arkansas and has been employed by the Southwestern Gas and Electric Company since 1932. He received the appointment of Chief Engineer in 1941. Mr. Sharp was Chairman of the Shreveport Section of AIEE from 1947 to 1948.

J. H. Burrus, Jr. (A '47), Manager of the Portland (Oreg.) district, Allis-Chalmers Manufacturing Company, has been appointed manager of the Milwaukee (Wis.) district. Mr. Burrus has been with Allis-Chalmers since 1937 and is an electrical engineering graduate of Texas Agricultural and Mechanical College. He was appointed manager of the Portland district in 1949.

I. G. Easton (A '41, M '49), Engineer, General Radio Company, New York, N. Y., has been transferred to the Cambridge, Mass., office.

OBITUARY....

Charles Edward Skinner (A '99, M '03, F '12, Honorary Member 1945, Member for Life), President of AIEE from 1931 to 1932, died May 12, 1950. Dr. Skinner was born in Redfield, Ohio, on May 30, 1865, and was educated at Ohio University and Ohio State University. He was graduated from the latter with the degree of Mechanical Engineer in 1890. He received the honorary degree of Doctor of Science from Ohio University in 1927. In 1890, he joined the Westinghouse Electric and Manufacturing Company (now the Westinghouse Electric Corporation) and remained with the company until his retirement in 1932. While with Westinghouse, Dr. Skinner was instrumental in organizing the company's insulation testing, magnetic testing and developing of magnetic materials, material specifications work, process engineering work, and the research division of the engineering department. He was also responsible for the organization and equipment of the Chemical Physical and Process Laboratories, as well as the High-Tension Test Laboratory. In addition, he had charge of building, equipping, and manning a new Research Laboratory. He retired as Assistant Director of Engineering. In 1906, Dr. Skinner went to Brussels, Belgium, as an American representative of the International Association for Testing Materials. In 1920 he was Chairman of the American Delegation to the Brussels Meeting of the International Electrotechnical Commission, and held a similar position at the meeting of the International Electrotechnical Commission in Geneva, Switzerland, in the fall of 1922. He was a member of the American Delegation to the Commission meeting in London, England, in 1924; The Hague, Holland, in 1925; New York, N. Y., in 1926; and Bellagio, Italy, in 1927. He was a delegate to the World Power Conference in London, England, in 1924. Dr. Skinner was Chairman of the American Engineering Standards Committee from 1925 to 1927, and it was during his incumbency in this office that the committee was reorganized as the American Standards Association. He was a member of the Board of Directors of the American Standards Association for a number of years. As Chairman of the American Engineering Standards Committee, he was elected Chairman of the committee of the organization of the International Standards Association, which met in New York, N. Y., in the spring of 1926 and in the fall of the same year. Dr. Skinner was the American member of the Committee of Seven Nations to perfect this organization. He was for many years an active member of the Engineering Council and of its successor the American Engineering Council. He served as a delegate to the International Engineering Congress held in Japan in 1929 and as Chairman of the American Electrochemical Society's delegation and a member of the American Standards Association's delegation to the Congress. Dr. Skinner actively served the Institute throughout his membership. In addition to being President from 1931 to 1932, he was Manager from 1915 to 1919, and Vice-President from 1919 to 1920. He also served on many committees and was Chairman of the Lamme Medal Committee from 1932 to 1935 and the Special Committee on History of Electrical Industry from 1932 to 1934. Dr. Skinner also was the Institute representative on ten other bodies. He was a member of the Franklin Institute, American Society for Testing Materials, Fellow of the American Association for the Advancement of Science, member of The American Society of Mechanical Engineers, the National Electrical Manufacturers Association, the American Physical Society, and the American Electrochemical Society.

Trygve D. Yensen (A '09, M '23), retired, died July 2, 1950. Dr. Yensen had just retired as manager of the Magnetic Department of the Research Laboratories of the Westinghouse Electric Corporation in East Pittsburgh, Pa. Dr. Yensen was born in Drammen, Norway, on January 30, 1884, and received the degrees of Bachelor of Science (1907), Master of Science (1911), and Electrical Engineer (1912) from the University of Illinois. In 1927, he received the degree of Doctor of Philosophy in Physics from California Institute of Technology. Dr. Yensen first worked for General Electric Company and then taught at the University of Illinois. For two years he was construction engineer with a Montreal, Quebec, Canada, water power company. In 1916, Dr. Yensen joined Westinghouse as a research engineer and, in 1923, he discovered a super-magnetic alloy which he called hipernick. In 1947, he perfected another alloy, Hiperco, an iron-cobalt combination capable of withstanding intense vibration. He had many papers published in technical journals on magnetism and magnetic materials and held several patents in the same field. Dr. Yensen was serving the Institute as a member of the Basic Sciences Committee, of which he had been a member since 1947. He was a member of the American Institute of Mining and Metallurgical Engineers, the American Society for Metals, and a fellow of the American Physical Society.

Gustav Frederick Wittig (A '05, Member for Life), retired, died May 30, 1950. Professor Wittig was born in New Brunswick, N. J., on September 15, 1876, and received a Bachelor of Science degree from Rutgers University in 1896 and an electrical engineering degree from Columbia University in 1904. He taught in New Brunswick High School following graduation from Rutgers and, in 1906, went to the University of Maine as assistant professor of electrical engineering. In 1909, he became head of the department of physics and electrical engineering at the University of Alabama. He was a member of the faculty school for training officer candidates for the United States Signal Corps at Yale University in 1918 and later he was a professor of electrical engineering at Yale. In 1926, Professor Wittig accepted a position as statistical editor of *Electrical World* and remained in that capacity until 1941, when he retired. He was a member of Tau Beta Pi.

Richard Loose Laudenslager (A '32, M '49), Assistant Professor of Electrical Engineering, University of Connecticut, Storrs, died June 2, 1950. Professor Lauden-

slager was born on October 6, 1906, in Worcester, Pa., and received an electrical engineering degree from Lehigh University in 1928. He was associated with the Brooklyn (N. Y.) Edison Company from 1928 to 1938, first as a student engineer and then as division engineer of the General Engineering Division. From 1938 to 1942 he was with the Consolidated Edison Company of New York as an assistant engineer. He became associated with the Stone and Webster Engineering Corporation, Boston, Mass., from the beginning of World War II until 1948, in the capacity of electrical engineer working on power plant design. In 1948 he was appointed to the electrical engineering faculty at the University of Connecticut and, in addition to his teaching responsibilities, had been active as a consulting engineer concerned with power system development in Connecticut. Professor Laudenslager served as a member of the Executive Committee of the Connecticut Section of AIEE from 1949 until his death. He was a member of Eta Kappa Nu and the American Society for Engineering Education.

Samuel Howard Rippey (A'04, M'12, F'12), retired, died on May 18, 1950. He was born in Philadelphia, Pa., on July 11, 1875, and was educated at Drexel Institute of Technology. Mr. Rippey entered the employment of the late Dr. Coleman Sellers, at that time President and Chief Engineer of The Niagara Falls Power Company and Canadian Niagara Power Company. In 1902, he was admitted to an interest in the practice of Dr. Sellers, and, in 1906, became a member of the new firm of Sellers and Rippey. Upon the death of Dr. Sellers, Mr. Rippey became the head of this firm, and continued as such until his retirement. Mr. Rippey was a Life Member of the American Society of Civil Engineers and a member of The American Society of Mechanical Engineers.

MEMBERSHIP . . .

Recommended for Transfer

The Board of Examiners at its meeting of June 15, 1950, recommended the following members for transfer to the grade of membership indicated. Any objections to these transfers should be filed at once with the Secretary of the Institute. A statement of valid reasons for such objections must be furnished and will be treated as confidential.

To Grade of Fellow

Craig, C. F., vice-pres., American Telephone & Telegraph Co., New York, N. Y.
Coleman, J. O., elec. engr., Stone & Webster Engineering Corp., Boston, Mass.
Ffolliott, C. F., director, product design sec., Automatic Electric Co., Chicago, Ill.
Hancock, M. S., asst. to genl. mgr., Westinghouse Electric Corp., Buffalo, N. Y.
Lynn, C., mgr., D-C engg. dept., Westinghouse Electric Corp., East Pittsburgh, Pa.
Ruggles, L. L., chief sales engr., Automatic Electric Sales Corp., Chicago, Ill.
Waite, L. O., elec. engr., Stone & Webster Engg. Corp., Boston, Mass.

7 to grade of Fellow

To Grade of Member

Adams, M. J., application engr., Westinghouse Electric Corp., Chicago, Ill.
Andreasen, I. E., industrial app. engr., General Electric Co., Schenectady, N. Y.
Armstrong, D. E., motor engr., Westinghouse Electric Corp., Buffalo, N. Y.
Axelsson, R., elec. designer, Pioneer Service & Engineering Co., Chicago, Ill.
Barnes, D. M., vice-pres. & chief engr., Associated Telephone Co., Ltd., Santa Monica, Calif.
Bartucci, J. V., asst. chief designer, Pioneer Service & Engineering Co., Chicago, Ill.
Berry, J. H., asst. elec. engr., Pioneer Service & Engineering Co., Chicago, Ill.
Best, G. R., sales engr., General Electric Co., Los Angeles, Calif.
Black, R. A., elec. engr., General Electric Co., Schenectady, N. Y.
Bodine, F. E., asst. central station mgr., Westinghouse Electric Corp., San Francisco, Calif.
Brumbaugh, C. J., engr., New York Telephone Co., Buffalo, N. Y.
Butts, C. A., signal engr., Chicago Transit Authority, Chicago, Ill.
Carpenter, C. A., assoc. engr., Union Oil Co. of California, Wilmington, Calif.
Christensen, M. M., asst. prof., University of Utah, Salt Lake City, Utah.
Danaher, J. J., Jr., elec. engr., Corps of Engineers, Mobile, Ala.
Davis, G. A., system planning div. engr., Southern California Edison Co., Los Angeles, Calif.
D'Azzo, J. J., asst. prof., elec. engg., U.S.A.F. Institute of Technology, Dayton, Ohio.
deBettencourt, M. A., pres., Intercoastal Electric Co., Houston, Tex.
Dimond, H. M., design engr., General Electric Co., Schenectady, N. Y.
Dinapoli, D. P., asst. engr., Pacific Gas & Electric Co., San Francisco, Calif.
Duenke, G. A., elec. engr. Moloney Electric Co., St. Louis, Mo.
Erven, J. W., elec. engr., dept. of water & power, City of Los Angeles, Los Angeles, Calif.
Giobbi, J., engr. & estimator, Garnet Electric Co., Florence, Ala.
Gow, K. P., senior design engr., Cooperative Wind Tunnel, Pasadena, Calif.
Heineck, W. A., elec. design engr., The Washington Water Power Co., Spokane, Wash.
Henry, L. H., elec. engr., frigidaire div., General Motors Corp., Dayton, Ohio
Hovarka, E., engr., The Ohio Bell Telephone Co., Cleveland, Ohio
Howell, W. D., div. sales mgr., Pacific Gas & Electric Co., Oakland, Calif.
Jirka, F. J., design engr., Public Service Co. of Northern Illinois, Chicago, Ill.
Johnstone, B. B., acting chief, physics group, air research, Air Materiel Command, Dayton, Ohio
Jones, J. W., senior engr., Philadelphia Electric Co., Phila., Pa.
Jones, M. A., engr., New Jersey Bell Telephone Co., Newark, N. J.
Kearney, J. W., engr., Airborne Instruments Lab., Inc., Mineola, N. Y.
Kirkpatrick, E. L., asst. physics prof., North Dakota Agricultural College, Fargo, N. Dak.
LaPierre, W. A., asst. prof., Columbia University, New York, N. Y.
Lawrence, R. F., central station engr., industry engg. dept., Westinghouse Electric Corp., East Pittsburgh, Pa.
Leal, A. H., chief, studies & standards div., The Rio de Janeiro Tramway, Light & Power Co., Ltd., Rio de Janeiro, Brazil
Lewis, W. A., Jr., plant engr., Reynolds Metals Co., Malvern, Ark.
Lischer, L. F., engr., Commonwealth Edison Co., Chicago, Ill.
Lyle, G. H., instructor, J. Sterling Morton High School & Junior College, Cicero, Ill.
Mason, M. F., relay engr., The Ohio Public Service Co., Elyria, Ohio
McFall, R. W., section engr., genl. engg. & consulting lab., General Electric Co., Schenectady, N. Y.
Moody, A. W., sales engr., General Electric Co., San Francisco, Calif.
Mothersead, C. T., equipment & buildings engr., Chesapeake & Potomac Telephone Co., Washington, D. C.
Mulhern, M. J., development engr., tube div., General Electric Co., Schenectady, N. Y.
Pearl, A. S., secy.-treas., The Delta-Star Electric Co., Chicago, Ill.
Phillips, C. H., div. dial eqpt. engr., Southern Bell Telephone & Telegraph Co., Nashville, Tenn.
Pickering, W. H., elec. engg. professor, California Institute of Technology, Pasadena, Calif.
Powell, F. C., elec. engg. prof., Drexel Institute of Technology, Philadelphia, Pa.
Prise, W. J., asst. mgr., industrial dept., The Maintenance Co., New York, N. Y.
Quigley, A. J., asst. prof., elec. engg., University of Notre Dame, Notre Dame, Ind.
Reid, T. H., senior elec. engr., dept. of lighting, City of Seattle, Seattle, Wash.
Richardson, B. R., elec. supt., Western United Gas & Electric Co., Aurora, Ill.
Robertson, J. A., Sr., plant engr., The Chesapeake & Potomac Telephone Co., Washington, D. C.
Schwarz, R. J., asst. prof., elec. engg., Columbia University, New York, N. Y.
Shaul, L. K., proposition engr., General Electric Co., Schenectady, N. Y.
Shirkey, P. C., Jr., sales engr., General Electric Co., Cleveland, Ohio
Sills, E. H., product engr., General Electric Co., Schenectady, N. Y.
Simonson, M. L., estimating engr., Oklahoma Gas & Electric Co., Oklahoma City, Okla.
Squire, E. T., supt., central office switchboard installation, Canadian (B. C.) Telephones & Supplies, Vancouver, Canada
Stamper, G., design engr., Dayton Power & Light Co., Dayton, Ohio
Teasdale, A. R., Jr., asst. prof. elec. engg., University of Texas, Austin, Tex.
Thayer, H. C., Jr., engr., Western Electric Co., Inc., Chicago, Ill.
Traub, L. A., transmission supv., The Pacific Telephone & Telegraph Co., Seattle, Wash.
Waller, M. J., radio transmitter engr., Northern Electric Co., Ltd., Belleville, Ontario, Canada
Weppler, H. S., meter relay & communications engr., Hydro Electric Power Commission of Ontario, Toronto, Ontario, Canada
Westermeyer, P. H., design engr., Westinghouse Electric Corp., Cincinnati, Ohio
Wright, J. A., planning engr., Tide Water Power Co., Wilmington, Del.

68 to grade of Member

Applications for Election

Applications for admission or re-election to Institute membership, in the grades of Fellow and Member, have been received from the following candidates, and any member objecting to election should so notify the Secretary before August 25, 1950, or October 25, 1950, if the applicant resides outside of the United States, Canada, or Mexico.

To Grade of Fellow

Boyse, C. O., British Insulated Callender's Construction Co. Ltd., London, England
d'Ombrain, G. L., Battersea Polytechnic, London Univ., London, England
Friauf, J. B., Bureau of Ships, Navy Dept., Washington, D. C.

3 to grade of Fellow

To Grade of Member

Carlson, O. E., Servo-Tek Products Co., Paterson, N. J.
Chamberlain, N. H., Clough Smith Co. Ltd., Redhill, Surrey, England, c/o Anglo-Iranian Oil Co., Abadan, Iran
Clark, E. K., Westinghouse Elec. Corp., Mansfield, Ohio
Cyr, A. J., New Brunswick Elec. Power Comm., Fredericton, New Brunswick, Canada
Doremus, J. A., Motorola, Inc., Chicago, Ill.
Foy, W. J., Mountain States Tel. & Tel. Co., Phoenix, Ariz.
Graybill, H. W. (re-election), Railway & Industrial Engg. Co., Greensburg, Pa.
Hamer, W. J., Natl. Bureau of Standards, Washington, D. C.
Hodgkins, R. L., General Elec. Co., Philadelphia, Pa.
Howard, J. H., Huntington & Guerry Elec. Co., Greenville, S. C.
Hunkins, H. R., Federal Tel. & Radio Corp., Clifton, N. J.
Knights, J. E., Jr., Reeves Instrument Corp., New York, N. Y.
Lehde, H. C., Control Instrument Co., Brooklyn, N. Y.
Lozier, J. C., Bell Tel. Labs. Inc., Murray Hill, N. J.
Manley, J. E., Municipality of Kalgoorlie, West Australia
Miller, D. B., Coyne Elec. School, Chicago, Ill.
Moore M. G., Empresa Nacional de Electricidad S. A., Santiago, Chile, S. A.
Perry, P. G., Battelle Memorial Inst., Columbus, Ohio
Pipes, L. A., Univ. of California, Los Angeles, Calif.
Romans, H., BEPCO Co. Ltd., Montreal, Quebec, Canada
Syron, W. M., S. W. Bell Tel. Co., Tulsa, Okla.
Van Blerkom, L., Weston Elec. Instrument Corp., Newark, N. J.
Weiss, H. K., Ballistic Research Labs., Aberdeen Proving Ground, Md.
White, A. B., Maujer Publishing Co., St. Joseph, Mich.
Wideman, N. E., Hydro Elec. Power Comm. of Ontario, Hamilton, Ontario, Canada
Wundt, R. M., Wright-Patterson Air Force Base, Dayton, Ohio

26 to grade of Member

Report of the Board of Directors

THE BOARD OF DIRECTORS of the American Institute of Electrical Engineers presents to the membership its 66th annual report, covering the fiscal year ending April 30, 1950. It contains a brief summary of the principal activities of the Institute during the year, a general balance sheet showing the financial condition of the Institute at the close of the fiscal year, a statement of cash receipts and disbursements, and a schedule of securities owned. Much additional information regarding the activities appeared in various issues of *Electrical Engineering*.

BOARD OF DIRECTORS' MEETINGS

Five meetings of the Board of Directors were held during the year, two in New York, N.Y., one in Swampscott, Mass., one in Cincinnati, Ohio, and one in Providence, R.I.

Information regarding many of the more important matters which were considered by the Board of Directors appeared in various issues of *Electrical Engineering*.

INSTITUTE POLICY

As a result of many discussions, in meetings of the Board of Directors and other groups, regarding proposals that the Institute participate in various activities of the broader, nontechnical types, a resolution intended to define the Institute as "strictly a scientific and educational organization" was discussed for several hours in the April 1949 meeting of the Board of Directors.

The resolution was referred to a special committee whose assignment was to stimulate discussion and consideration of the subject both in the next meeting of the Section Delegates and in the Sections, and to report to the Board of Directors not later than the time of the Board meeting at the 1950 Winter General Meeting.

All Sections were requested to urge their members to vote upon the following two courses:

1. I favor adhering to the technical field.

2. I favor expanding in nontechnical field with increased dues.

The vote was 7,245 in favor of proposition 1, and 2,063 in favor of proposition 2.

The special committee presented to the Board of Directors, on February 2, the following proposals of policy:

1. The Board of Directors will work continually for the unification of the profession.

2. The Board of Directors recognizes the fact that the Institute finds its chief reason for existence in the technical field.

3. The Board of Directors will handle questions on nontechnical affairs as necessary and as they arise, on an emergency basis until through unification they can be handled on a general professional basis.

The Board of Directors approved the recommendation that these three proposals be published in *Electrical Engineering* for March, with a report on the vote conducted by the Sections, and a return postal card, on which each member was requested to approve or disapprove each of the three proposals.

At the meeting of the Board of Directors in Providence, on April 27, the following results, to April 14, were reported:

Proposal	Number 1	Number 2	Number 3
Approved	3,391	3,386	3,331
Disapproved	252	290	312

The time for conclusion of the ballot was extended to May 15.

INSTITUTE VISITS BY PRESIDENT FAIRMAN

California
Pacific General Meeting, San Francisco; Summer and Pacific General Meeting, Pasadena

Florida
Florida Section, Gainesville

Georgia
Georgia Section, Atlanta

Illinois
Urbana Section; Illinois Valley Section, Peoria

Indiana
Fort Wayne Section

Iowa
Iowa Section and Iowa State College Branch, Des Moines

Kentucky
Louisville Section

Louisiana
Shreveport Section; New Orleans Section

Maryland
Maryland Section, Baltimore

Michigan
Great Lakes District Meeting, Jackson; University of Michigan Branch, Ann Arbor

Minnesota
Minnesota Section, Minneapolis

Nebraska
Nebraska Section and University of Nebraska Branch, Omaha

New York
Winter General Meeting, New York; New York Section; Niagara Frontier Section, Buffalo

North Carolina
North Carolina Section, Winston-Salem

Ohio
Columbus Section; Fall General Meeting, Cincinnati; Cleveland Section

Oklahoma
Oklahoma City Section; Tulsa Section

Oregon
Portland Section

Pennsylvania
Pittsburgh Section and Carnegie Institute of Technology, Pennsylvania State College, University of Pittsburgh, and University of West Virginia Branches, Pittsburgh; Philadelphia Section; Lehigh Valley Section, Sunbury

Rhode Island
North Eastern District Meeting, Providence

South Carolina
South Carolina Section, Columbia

Tennessee
East Tennessee Section, Chattanooga

Texas
Panhandle Plains Section, Amarillo; South Texas Section, San Antonio; Houston Section; Beaumont Section

Utah
Utah Section, Salt Lake City

Virginia
Virginia Section, Richmond; Western Virginia Section Roanoke

Washington
Seattle Section; Spokane Section

West Virginia
West Virginia Section, Charleston

Wisconsin
Madison Section; Milwaukee Section

ANNUAL MEETING

The 66th annual business meeting of the Institute was held in Swampscott, Mass., June 22, 1949. The annual report of the Board of Directors for the fiscal year which ended April 30, 1949, was presented in abstract by Secretary H. H. Henline, who also presented a report of the Committee of Tellers on the vote of the membership on the election of officers whose terms were to begin on August 1, 1949. In the absence of Treasurer W. I. Slichter, his report on Institute finances was presented by Secretary Henline. President-elect James F. Fairman was introduced, and responded with a brief address.

The Lamme Medal for 1948 was presented to Dr. V. K. Zworykin, Vice-President and Technical Consultant, Radio Corporation of America Laboratories Division, Princeton, N.J.

An address, "The Expanding Horizons in Engineering Education," was given by William F. Ryan, Engineering Manager, Stone and Webster Engineering Corporation. Preceding his address, Mr. Ryan, as Vice-President of the Northeastern Section of the National Society of Professional Engineers, presented to Mr. Fairman a tribute of esteem from his friends in many parts of the United States, a richly bound volume of congratulatory letters from officers of the NSPE and the presidents of many of the state societies.

The last item on the program was an inspiring address entitled "Open Doors," by President Everett S. Lee.

GENERAL MEETINGS

Four general meetings were held during the year, and a brief report on each follows:

Summer General Meeting. The 65th Summer General Meeting was held in Swampscott, Mass., June 20–24, 1949, with a registration of 1,650. The program included 30 technical sessions and conferences, the official annual business meeting of the Institute, 50 committee meetings, Section Delegates conferences, and a meeting of the Board of Directors. Social and entertainment features included a barn-dance, President's reception and banquet, New England entertainment, and special events for the ladies. Various types of inspection trips were available.

Pacific General Meeting. The Pacific General Meeting was held in San Francisco, Calif., August 23–26, 1949, with a registration of 878. There were a general session ad-

dressed by W. C. Mullendore, President, Southern California Edison Company, Ltd.; a luncheon meeting addressed by President Fairman; 15 technical sessions and conferences; two student sessions; a meeting of District, Section, and national officers, and Branch Counselors; a meeting of Branch officers and Counselors; a banquet; a student dinner and meeting; inspection trips; golf tournament; and ladies' events.

Fall General Meeting. The third Fall General Meeting was held in Cincinnati, Ohio, October 17–21, 1949. The registration was 1,045. The program included a general session with three addresses, by President Fairman, Dr. Raymond Walters, President of the University of Cincinnati, and Robert S. Peare, Vice-President in charge of Public Relations, General Electric Company; 31 technical sessions and conferences; a luncheon and session at the University of Cincinnati for discussion of intersociety relationships in Cincinnati; inspection trips; a dinner-dance; and an extensive ladies' program. Also, a meeting of the Board of Directors, a District Executive Committee meeting, and about 40 committee meetings were held.

Winter General Meeting. The Winter General Meeting was held in the Hotel Statler, New York, N. Y., January 30–February 3, 1950, with a registration of 3,213, and a record program of 58 technical sessions and conferences, and presentation of 243 papers. In a general session, addresses were given by Harold E. Stassen, President, University of Pennsylvania, and Sir Ernest Benn of London, England (in absentia), and an Honorary Member certificate was presented to Dr. Vannevar Bush, President, Carnegie Institution of Washington. Approximately 90 meetings of technical and administrative committees and a meeting of the Board of Directors were held. In addition, there were inspection trips, a smoker, a dinner-dance, and ladies' entertainment events.

DISTRICT MEETING

North Eastern District Meeting. A North Eastern District Meeting was held in Providence, R.I., April 26–28, 1950, with headquarters at the Sheraton-Biltmore Hotel. The registration was 502. The meeting consisted of eight technical sessions, two student technical sessions, a luncheon meeting of Branch Chairmen and Counselors, inspection trips, two banquets, and ladies' events. A meeting of the Board of Directors, a conference of Vice-Presidents, and a meeting of the District Executive Committee were held.

SPECIAL TECHNICAL CONFERENCES

"Special Technical Conferences" were inaugurated in 1948, and have proved so successful that the number being planned and held has increased rapidly. The conferences are intended to be national in interest, technical in character, and concentrated as to subject matter toward one particular industry or objective. This type of meeting is designed to explore thoroughly a limited field and to afford specialists in that field an opportunity to discuss mutual technical problems. The conferences may be defined as a program of panel discussions, technical papers, or exhibits under the auspices of a national technical committee, in co-operation with an AIEE local Section, which might act as host to the conference. Operating under the policy and procedure which has been set up, the following conferences were held during the past fiscal year.

Conferences on the Textile Industry. Electrical engineering problems in the textile industry was the subject of two technical conferences held in May 1949. The first was in Boston, Mass., May 3, and was sponsored by the Textile Industry Subcommittee of the Committee on General Industry Applications, in co-operation with the Boston Section. Seven papers and two moving pictures were presented during the two sessions of the conference. Subjects covered by the papers ranged from cloth production in the loom to cloth finishing. The attendance was 65. Approximately 95 persons attended the conference at the Georgia Institute of Technology, Atlanta, Ga., May 27–28, which was sponsored also by the Textile Industry Subcommittee, in co-operation with the Engineering Extension Division of the Georgia Institute of Technology and the Georgia Section. Among the many interesting subjects discussed were electric equipment for textile machines, loom research, fire hazards, electrostatic air cleaning, and so forth. Proceedings of these conferences have not been published, but some digests of the papers presented appear in the September 1949 issue of *Electrical Engineering.*

Conference on Electric Equipment for Materials Handling Bridges was held in Cleveland, Ohio, May 13, 1949, sponsored by the Materials Handling Subcommittee of the Committee on General Industry Applications and the Cleveland Section. The topic of "Electric Equipment for Materials Handling Bridges" was considered in several prepared papers, followed by round-table discussion. The attendance was 85.

Conference on Electronic Instrumentation in Medicine and Nucleonics was held in New York, N. Y., October 31, November 1–2, 1949, sponsored jointly by committees of AIEE and the Institute of Radio Engineers. The sponsoring committees included:

For AIEE: Committee on Nucleonics, Committee on Electronics, Committee on Instruments and Measurements, Joint Subcommittee on Nucleonic Instrumentation, Joint Subcommittee on Electronic Aids to Medicine

For IRE: Professional Group on Nuclear Science, Nuclear Studies Committee

The first day of the 3-day gathering was devoted to the nonnucleonic phases of electronics in medicine. The second day's sessions dealt with nucleonics in medicine. A round-table discussion on "Evaluation of Radiation Hazards" was held during the evening of the second day. The last day's sessions were concerned with nucleonic developments in industry and government. Six sessions provided for the presentation of 21 papers, in addition to the discussions and address which were a part of the round-table discussion panel held in the evening. More than 800 persons attended the conference, and an interesting and very popular feature was an exhibit of commercially available nucleonic equipment. Complete proceedings of the conference have been printed in book form and are available at a price of $3.50.

Conference on Electric Welding was held at the Rackham Memorial Building, Detroit, Mich., April 5–7, 1950, sponsored by the Committee on Electric Welding, in co-operation with the American Welding Society and the Industrial Electrical Engineers' Society in Detroit. The conference, which was the second Welding Conference, provided an opportunity for the presentation in six sessions of 24 papers on arc and resistance welding. Two of the evenings were devoted to demonstrations of electric welding techniques and equipment. These included several inert gas welding processes, stud welding, submerged arc welding, a 3-phase rectifier-type d-c arc welder, portable gun welding, and resistance welding controls. The total attendance at the conference was 420. The papers and discussions will be published in a bound volume at a price of $3.50.

Conference on Electric Space Heating was held at the Rogue Valley Country Club, Medford, Oreg., on April 12, 1950, sponsored by the Committee on Domestic and Commercial Applications. This was a 1-day meeting with a general session in the evening. No prepared papers were presented, but for those wishing to present technical data there was a preliminary meeting in the afternoon to make arrangements so that everyone who was interested could be heard. Subjects discussed were domestic heating, domestic load control, and heat pump performance. The attendance was 34.

The Second Southern Conference on Electrical Application for the Textile Industry was held at the Georgia Institute of Technology, Atlanta, Ga., April 13–14, 1950, sponsored by the AIEE Textile Industry Subcommittee of the Committee on General Industry Applications, and the Georgia Institute of Technology. Three sessions at this conference provided for the presentation of nine papers, which were arranged to keep the persons in the textile field informed on new scientific and engineering developments which are in progress. The subjects covered packaged drives, power wiring, lighting, electronics, and air conditioning. The attendance was 210. A Conference on Textiles for New England was incorporated as a session, on April 27, of the North Eastern District Meeting, which was held in Providence, R. I. Four papers were presented at this session, and an inspection was made on the same day of the Owens-Corning Fiberglas Corporation plant at Ashton, R. I. The attendance at the session was 126.

Power Conference. The Pittsburgh Section was host to a 2-day Power Conference in Pittsburgh, Pa., April 19–20, 1950, sponsored by the Committees on Industrial Power Systems, Power Generation, and System Engineering. A well diversified program was planned to attract as large an attendance as possible and ensure active discussion. This resulted in the presentation of 18 papers in four sessions, and all proved of practical interest to central-station and industrial plant designers and operators. This was the first technical conference to be sponsored by a committee within the Power Group, but was most successful, with an attendance of 300. Published proceedings of this conference will be available at a price of $2.50

General Committees

BOARD OF EXAMINERS

The Board of Examiners, for the first time in many years, has been able to conduct its business at the regularly scheduled monthly meetings, without having to hold extra sessions.

Table I. Applications for Admission and Transfer, 1949–1950

Applications for Admission		
Recommended for grade of Associate	3,792	
Re-elected to the grade of Associate	90	
Not recommended	8	
		3,890
Recommended for grade of Member	324	
Re-elected to the grade of Member	19	
Not recommended	73	
		416
Recommended for grade of Fellow	4	
Not recommended	0	
		4
Applications for Transfer		
Recommended for grade of Member	560	
Not recommended	45	
		605
Recommended for grade of Fellow	115	
Not recommended	1	
		116
Students		
Recommended for enrollment as Students		7,733
Total		12,764

Statistics relating to the number of cases handled by the Board are given in Table I. The current total, excluding "enrolled Students," is four per cent less than for 1948–49. This is largely due to a decrease in Associate applications, which have dropped seven per cent. Student enrollments have dropped 12 per cent. The decrease in Associate applications and in Students' enrollments was not unexpected, both being largely affected by enrollments in colleges under the "GI Bill of Rights."

COMMITTEE ON CODE OF PRINCIPLES OF PROFESSIONAL CONDUCT

Two matters were carried over from the preceding year. The first was the case of the Southwestern Power Administration in advertising for competitive bids for professional electrical engineering services. Formally, that matter was closed two years ago with this committee's report to the Board of Directors (in which it was found that there had been no violation of the Canons of Ethics of the Engineers' Council for Professional Development, or of the Institute Code. The committee's belief was reported that such practices should not be encouraged and that necessity for them by such a governmental agency should be removed by legislative or executive action). This matter has been before the committee this year only through copies received of correspondence of the Institute President and the Southwestern Power Authority aimed to find out if the prior technical difficulties had been removed. However, the question of competitive bidding is a live matter, being discussed by regional engineering associations, and this subject could well be continued by this committee.

The second matter carried over was the projected "Statement of Principles of Professional Conduct" combining the Canons of Ethics of the Engineers' Council for Professional Development, verbatim, with certain rules of practice contained in the old Code of the Institute. It was thought that a draft had been agreed upon for submission when a new matter arose which led to a recommendation to change the Institute Bylaws. That change suggested a change or addition to the pending "Statement of Principles" which has held up the presentation. It is expected that this whole matter can be closed during the current administrative year.

One new matter arose during the year. A case was reported to the Institute, and referred to the committee, where an electrical contractor who was an Associate did business under a corporation name, and carried insignia of the Institute on corporation letterhead and advertising. The committee believed that the Associate in question had merely not appreciated the distinction between the Institute and contractors' associations by which such practices are approved. It was emphasized that membership in the Institute is a wholly personal and professional matter, that insignia are to be displayed only on Institute letters and publications, except of course in the wearing of membership badges and use of personal membership statements on stationary, and so forth. A change in the Bylaws clarifying this whole situation was recommended to the Directors and adopted by them. It now rests with the Committee on Constitution and Bylaws. A corresponding addition to the projected "Statement of Principles of Professional Conduct" is being considered.

COMMITTEE ON CONSTITUTION AND BYLAWS

This committee submitted certain recommendations to the Board of Directors in advance of three meetings, and the Bylaws were amended as outlined in the following.

June 23, 1949. A change was made in Section 19 to clarify the time of notification of Members for Life.

A change was made in Section 26 regarding the general meetings, identifying them as Winter General Meeting, Summer General Meeting, Pacific General Meeting, and Fall General Meeting.

Section 64 was amended to include certain new committees and rearrangement of the technical committees.

October 20, 1949. Sections 6 and 7 were amended so as not to require the publication in *Electrical Engineering* of the names of applicants for admission to the Institute as Associates.

February 2, 1950. Sections 10 and 17 were amended to clarify the requirements of notice regarding members in arrears.

The printing on the annual dues bill and each of the quarterly notices sent to those remaining in arrears of Sections 16, 17, 18, and 12 of the Bylaws, covering the billing of annual dues, delinquencies, and reinstatement, is now required by Section 17.

COMMITTEE ON EDUCATION

The committee sponsored three conference sessions as reported in the following paragraphs.

At the Summer General Meeting, the conference theme "Accrediting of Engineering Curricula" was dealt with in two talks, one on the accrediting program from the point of view of those administrating it, and the other on what the visitor sees. The purpose of the session was to provide an opportunity for Institute members to become acquainted with what the committee thinks is a powerful, but not very well known, influence in electrical engineering education.

At the Fall General Meeting, the conference subject was "Problem and Thesis Subjects From Industry." In three excellent papers presented by six engineers in industry, typical problems were presented, by example, from the fields of application, design, and industrial electronics. Such problems are of value to the teacher and student especially in bringing the point of view of the classroom closer to that of industry.

At the Winter General Meeting, the theme was "Post-College Development of Engineers." The five papers, resulting from studies made by the ECPD Committee on Professional Training, covered the various aspects of the subject: the orientation and training of the young engineer in industry, his continued education, methods for appraising himself, professional registration, and integrating him into his community. These were the basis of a spirited discussion, and should be of particular significance to the Institute, whose life and growth are in a large measure dependent upon the quality and attitudes of the young men from whose ranks it recruits its new members.

Four of the five papers of the first two conferences were published in *Electrical Engineering*, and a summary of the third conference is in prospect for publication.

The conference scheduled for the Summer and Pacific General Meeting deals with the planning of new electrical engineering laboratory facilities for colleges. Quite a number of new laboratories have been built in recent years, and others are in the planning stages; hence, the conference should serve as a medium for the exchange of ideas.

Future work of the committee is expected to include studies through subcommittees, of the following subjects: objectives of the electrical engineering curriculum, graduate programs, measuring the effectiveness of educational programs, and accrediting. It is expected that these topics will be the subjects of future conferences.

FINANCE COMMITTEE

For the budget year October 1, 1949, to September 30, 1950, the Board of Directors adopted a balanced budget, and the financial performance for the first six months of that period has been approximately in line with the budget provisions. Due to the fact that expenditures occur fairly evenly from month to month, but receipts are much greater after May 1 then they are prior to that time, it is necessary to engage in temporary transfers or borrowings during the later winter. This year is no exception, and $40,000 was transferred from the Reserve Capital Fund to the General Fund, which will be repaid from dues receipts after May 1.

The remedial factors mentioned in last year's report which are designed to ease the Institute's financial situation are in operation:

1. Increased advertising rates in *Electrical Engineering*.
2. Registration fees for general and District meetings.
3. More adequate price scales for Institute publications.
4. Excellent co-operation by committees responsible for sizable expenditures in the effort to live within budget limitations.

The results of these measures and others effective in the same direction were such as to remove the apparent immediate necessity for an increase in dues, so the Special Committee on Institute Dues was discharged with thanks.

It is recognized, however, that the financial picture can change radically with great speed, due both to substantial decreases in income

and to a sustained upward trend in expenditures, so the necessity for continued vigilance in financial matters is just as important now as it has been. So far, income is holding up very well, but items tending to enlarge the size of expenditures are constantly appearing. Publication costs, both for material and production, are still going up; appropriations to other organizations, maintained in part by the Institute, are increasing; a study has been made of the Institute traveling allowances, with the view of making them more adequately compensatory under present conditions; to mention only a few such influences.

The Reserve Capital Fund is the Institute's "anchor to windward," and it is available to permit the maintenance unimpaired of our present activities during any probable necessary period for the adjustment of our financial requirements to a new situation.

HEADQUARTERS COMMITTEE

The chief activity of this committee concerned the study and application of air-conditioning equipment for all office space at Headquarters. In accordance with a recommendation to the Board of Directors, a special grant was authorized and an order placed for the installation of 21 units. At the time of this report, the installation is practically complete, and it is expected that considerable increase in office efficiency will result during the summer months.

The committee also continued the program of modernization of lighting fixtures with the installation of additional fluorescent units in several offices. Replacement of the fixtures in the Board of Directors' room with units of more modern design is under consideration, and will be accomplished in the near future.

The table in the Board of Directors Room was polished and provided with a new felt cover.

Other matters on the agenda concern the cleaning of rugs, shampooing of upholstered furniture, addition of identifying lettering on office doors, and a new bulletin board for the reception area.

COMMITTEE ON MANAGEMENT

The major question before the Committee on Management during the year was to decide whether such an activity fitted into the scope of the AIEE. To this end, a very complete questionnaire was circulated to the members of the committee, and a meeting was held in New York during the Winter General Meeting. As a result of this work, the committee had a part-session at the North Eastern District Meeting, and is organizing a session for the 1951 Winter General Meeting, with a view to finding out the interest of the membership in such meetings.

It is believed that, as a result of these two sessions, the committee will be in a much better position to judge whether or not management should be a part of AIEE activities.

MEMBERSHIP COMMITTEE

Membership in the Institute increased by 3,407 members in the year ending April 30, 1949. This was a 40-per cent greater growth than 1949, and the largest on record. Previous to this period, the maximum annual increase had been 2,018 in 1946. Table II of membership statistics shows the nature of the changes in membership during the year. The substantial growth reflects both the heavy graduation of electrical engineering students from the universities and the stepped-up activity of the Membership Committee itself. Of the total applications amounting to 6,450 received during the year, 4,033 were from students, and 2,417 from others. The total applications received include those of graduates who applied last June and who were not elected to Associate membership until April 1950. There were a total of 3,347 former Student members approved at this meeting. Apparently the new plan has stimulated interest among the graduating Student members.

A further stimulation to transfer has come from the accelerated activity of the Membership Committees among the college graduates during their first year out of school.

Members in arrears for dues for the fiscal year ending April 30, 1950, reached a total of 1,510 compared with 1,376 last year. This represents a delinquency of 0.442 per cent compared with 0.448 per cent a year ago, showing slight improvement. During the year, there were 682 members dropped compared with 685 for the previous year. On the other hand, the number resigning increased from 277 to 343, but this loss of membership is to be expected due to the larger number of members.

During the year, the Membership Committee completed work on a revised "Membership Information" pamphlet, under the subcommittee chairmanship of Walter Bloomquist. The new booklet was designed for wide distribution. It gives short statements on the value of membership in the Institute and eligibility requirements. It is thought that this will be a valuable tool for Membership Committees in the future.

The Subcommittee on Survey of Student Branches under the chairmanship of J. C. Woods, co-operating with the Committee on Student Branches, submitted its final report. The purpose of this committee was to organize and undertake a survey of Student Branch membership as a function of maximum potential membership at each school, and to investigate the policies surrounding and reasons for the acceptance of local members. Since

Table III. Number of Applications Received From Student Members and From All Others

Year Ending April 30	Students	All Others	Total
1950	4,033	2,417	6,450
1949	2,286	2,192	4,478
1948	1,481	2,272	3,753
1947	938	2,331	3,269
1946	308	2,453	2,761
1945	249	2,179	2,428
1944	466	1,908	2,374
1943	783	1,431	2,214

Table IV. Number of Student Members as of April 30

Year	New Applications	Renewals	Total
1950	7,876	12,792	20,668
1949	9,967	9,461	19,428
1948	7,876	6,041	13,917
1947	5,092	3,929	9,021
1946	2,574	2,513	5,087
1945	2,326	2,287	4,613
1944	2,242	2,656	4,898
1943	2,512	3,200	5,712

Table II. Membership Statistics for Fiscal Year Ending April 30, 1950

	Honorary Members	Fellows	Members	6-Year Associates	Associates	Subtotals	Total
Membership April 30, 1949	8	1,172	8,669	8,637	12,305		30,791
Additions							
New members qualified		3	261		4,078	4,342	
Former members reinstated or re-elected			86	74	113	273	
Subtotals		3	347	74	4,191	4,615	
Transfers	1	110	491	1,575		2,177	
Totals	1	113	838	1,649	4,191	6,792	
Deductions							
Died	1	27	84	49	22	183	
Resigned			45	163	135	343	
Dropped		2	84	230	366	682	
Subtotals	1	29	213	442	523	1,208	
Transfers		1	108	411	1,657	2,177	
Totals	1	30	321	853	2,180	3,385	
Net Changes		83	517	796	2,011	3,407	
Membership April 30, 1950	8	1,255	9,186	9,433	14,316		34,198

Table V. Record of AIEE Membership

Year	Total May 1	Year	Total May 1	Year	Total May 1
1884	71	1907	4,521	1929	18,133
1885	209	1908	5,674	1930	18,003
1886	250	1909	6,400	1931	18,334
1887	314	1910	6,681	1932	18,003
1889	333	1911	7,117	1933	17,010
1890	427	1912	7,459	1934	15,230
1891	541	1913	7,654	1935	14,269
1892	615	1914	7,876	1946	14,600
1893	673	1915	8,054	1937	15,308
1894	800	1916	8,202	1938	16,078
1895	944	1917	8,710	1939	16,605
1896	1,035	1918	9,282	1940	17,213
1897	1,073	1919	10,352	1941	17,886
1898	1,098	1920	11,345	1942	18,944
1899	1,133	1921	13,215	1943	20,161
1900	1,183	1922	14,263	1944	21,407
1901	1,260	1923	15,298	1945	23,072
1902	1,549	1924	16,455	1946	25,090
1903	2,229	1925	17,319	1947	26,470
1904	3,027	1926	18,158	1948	28,408
1905	3,460	1927	18,344	1949	30,791
1906	3,870	1928	18,265	1950	34,198

the Student members are the most important source of new Institute members, it was thought that maximum effort should be exerted in this field. It has been recommended that the Committee on Student Branches take an active interest in this subject and develop a uniform method of membership practices in the universities, which will stimulate student activities.

The committee wishes to commend the excellent co-operation and sincere efforts of the Section Membership Chairmen throughout the year. The increase in applications from other than Student members attests to the fact that they have been extremely active. The District Vice-Chairmen have increased their contact with the local Section Chairmen substantially, and this new method is also proving highly effective. The tremendous growth of the Institute indicates that sights should be raised above those of the past and serious consideration given to the day not far ahead when a membership of 50,000 will be reached.

COMMITTEE ON PLANNING AND CO-ORDINATION

The committee held its usual number of meetings during the year, each preceding by a few days a Board of Directors meeting.

Scheduling of Future Meetings. The future general and District meetings of the Institute have been scheduled up to and including 1952. The attempt to obtain spacing between District meetings, even though these are held in widely separated parts of the United States, has been continued. Consideration was given to respacing the general meetings with particular attention to the Fall and Winter General Meetings. After thorough study, however, the committee was convinced that the present procedure provides the best general schedule. With the assistance of the Technical Program Committee, an attempt is being made to swing papers from both the Summer and Winter General Meetings into the Fall General Meeting. A growing number of technical conferences is being arranged for and co-ordinated through the proper technical committees.

Registration Fees. The matter of registration fees to be charged at general and District meetings has been subjected to continuing review. There has been general acceptance of the present method and no change is contemplated.

Technical Activities. With the recommendation for the establishment of the Technical Advisory Committee, the Technical Activities Subcommittee, active since Dr. Wickenden's administration, will be disestablished.

Ex Officio Assignments. After a study of the large number of ex officio assignments which have grown up under the existing Bylaws, the committee has recommended the dropping of all such assignments in the Bylaws. This will tend to relieve the burden on some of the key committee positions and to distribute in more balanced fashion and to a greater number of members the administrative work of the Institute. As an instance, the Committee on Award of Institute Prizes, whose chairman in the past had been the Chairman of the Technical Program Committee, has been divorced completely from this ex officio relationship, and in the coming year will operate with a group of members who, while appointed from the technical committees, are not rigidly held to an ex officio group. Many other similar simplifications are in the process of being made.

Changes in District Setup. The study of redistricting done by the committee four years ago was brought out and re-examined with a recommendation for no change in the immediate future.

Emblem. Various suggestions as to special emblems to recognize specific offices and for change in design of the present emblem were reviewed, with the recommendation that the emblem design and procedure remain as at present.

PUBLICATION COMMITTEE

The publication services of the Institute can be divided into five broad classifications: *Electrical Engineering*, *Transactions*, *Proceedings*, Advance Pamphlet Copies of papers to be presented at meetings, and Special Publications. Provision for these publications was made in the policy which became effective January 1, 1947. The number of pages of published material for the calendar year

Table VI. Deaths of AIEE Members Reported in Electrical Engineering

Name	Date of Election	Date of Death	Grade at Death	Obituary Notice in Electrical Engineering
Appleyard, Arthur E.	A '96		M	June '49, p. 553
Atkins, David F.	A '07	Jan. 8, '49	M	Dec. '49, p. 1108
Austin, Eugene H.	M '42	Sept. 13, '49	M	Feb. '50, p. 177
Avery, Morton B.	M '24	Jan. 26, '50	M	May '50, p. 473
Bacon, Frank R.	A '10	Oct. 6, '49	M	Dec. '49, p. 1108
Ballantyne, William M.	A '21	Aug. 29, '49	M	Nov. '49, p. 1009
Barron, Jacob T.	A '07	Mar. 12, '50	F	May '50, p. 472
Bascom, Henry M.	M '19	Mar. 14, '50	F	May '50, p. 472
Berthold, Martin	A '08	Oct. 16, '49	M	Dec. '49, p. 1109
Blake, Samuel H.	A '03	Aug. 24, '48	F	Jan. '50, p. 87
Bogan, Louis E.	A '99	Dec. 3, '49	F	Feb. '50, p. 176
Bollaert, Remi	A '38	Dec. 2, '49	M	Feb. '50, p. 176
Borch, Frederik	A '08	Aug. 15, '49	F	Nov. '49, p. 1009
Brinckerhoff, Henry M.	A '96	Oct. 12, '49	M	Dec. '49, p. 1108
Brown, Jr., Charles E.	A '40	Nov. 8, '49	A	Jan. '50, p. 87
Burton, Paul G.	A '95	Nov. 14, '49	F	Mar. '50, p. 282
Clausen, Henry P.	A '03	Dec. 20, '49	M	Mar. '50, p. 283
Cluff, T. Walker	M '37	Nov. 6, '49	M	Jan. '50, p. 87
Collett, Charles O.	A '07	Oct. 15, '49	M	Jan. '50, p. 87
Creaghead, Thomas J.	A '93	Mar. 4, '50	A	May '50, p. 472
Dann, Norman L.	A '17	Oct. 27, '49	A	Jan. '50, p. 88
Dean, Samuel M.	A '25	May 31, '49	F	Aug. '49, p. 708
DeForest, Cornelius W.	A '07	Nov. 17, '49	F	Feb. '50, p. 176
Dickinson, William N.	F '35	Jan. 26, '50	F	Mar. '50, p. 379
Diederich, Peter	A '24	Nov. 1, '49	F	Jan. '50, p. 88
Doonan, Joseph J.	M '33	May 21, '49	M	Aug. '49, p. 709
Dueland, Rudolph	A '23	Nov. 8, '49	M	Feb. '50, p. 176
Dunn, John F.	A '07	Jan. 12, '50	M	May '50, p. 472
Ekern, Emil A.	A '04	Jan. 3, '50	M	May '50, p. 472
Ely, Robert B.	A '41	July 6, '49	A	Dec. '49, p. 1108
Ferguson, James W.	A '40	Jan. 3, '50	A	Mar. '50, p. 283
Ferguson, Samuel	A '02	Feb. 10, '50	A	May '50, p. 472
Finkle, Frederick C.	A '08	Apr. 7, '49	A	July '49, p. 638
Finlaw, John	A '35	Nov. 8, '49	A	Feb. '50, p. 177
Fish, Fred A.	A '00	May 20, '49	F	Sept. '49, p. 820
Flanders, Charles K.	A '19	Jan. 11, '50	M	May '50, p. 473
Goodman, Lynn S.	A '11	July 27, '49	M	Oct. '49, p. 903
Goutink, Norman J.	A '28	Mar. 21, '49	A	July '49, p. 638
Hall, Harry C.	A '01	June 20, '49	M	Oct. '49, p. 903
Hallenbeck, Charles S.	A '21	Jan. 2, '50	M	May '50, p. 473
Hodgkinson, Francis	A '02	Nov. 4, '49	A	Jan. '50, p. 86
Hoffman, William L.	M '41	Feb. 7, '49	M	June '49, p. 553
Jewett, Frank B.	A '03	Nov. 18, '49	F	Jan. '50, p. 86
Kearney, Sr., James R.	M '25	Oct. 4, '49	M	Jan. '50, p. 88
Kifer, Edwin H.	A '09	Apr. 14, '49	F	July '49, p. 638
Kuester, Albert J.	A '46	Feb. 22, '49	A	June '49, p. 553
Lawrence, William H.	A '99	Aug. 8, '49	M	Nov. '49, p. 1009
Lee, Jr., Addison W.	A '08	May 1, '49	M	July '49, p. 638
Leland, Cyrus A.	M '27	May 25, '49	M	Aug. '49, p. 708
Magraw, Lester A.	A '07	Mar. 25, '49	M	June '49, p. 553
Matthews, Howard D.	M '42	Feb. 28, '50	F	May '50, p. 472
Meyer, Grover C.	M '44	June 2, '49	M	Sept. '49, p. 820
Millar, Preston S.	A '03	June 17, '49	M	Sept. '49, p. 819
Morse, George H.	F '22	June 1, '49	F	Sept. '49, p. 819
Munoz, Cecil M.	A '16	July 6, '49	A	Oct. '49, p. 904
Murphy, John	A '00	Sept. 23, '49	F	Dec. '49, p. 1108
McAfferty, Herbert G.	A '36	Nov. 16, '49	A	Feb. '50, p. 177
McDermott, Franklin P.	A '07	Oct. 31, '49	A	Jan. '50, p. 88
McKenzie, Daniel A.	A '15		M	Feb. '50, p. 177
Price, Harold W.	A '03	Feb. 14, '50	M	May '50, p. 473
Rea, Norman L.	A '02	May 10, '49	A	Sept. '49, p. 819
Rice, Ivan S.	A '27	Aug. 11, '49	M	Dec. '49, p. 1109
Rogers, Fred A.	A '06	Mar. 18, '49	M	July '49, p. 638
Roper, Denny W.	A '93	Oct. 5, '49	F	Jan. '50, p. 86
Ross, William E.	M '38	May 5, '49	M	Aug. '49, p. 708
Ryan, John J.	M '23	Jan. 29, '50	M	Mar. '50, p. 282
Scarlett, Farrell M.	A '47	May 6, '49	A	July '49, p. 639
Schweitzer, E. O.	A '99	Sept. 22, '49	F	Dec. '49, p. 1108
Sisson, Charles E.	A '19		F	Feb. '50, p. 176
Smith, Walter E.	A '00	Apr. 21, '49	A	July '49, p. 639
Stearns, William G.	A '35	Jan. 3, '50	A	Mar. '50, p. 283
Stoddard, Raymond R.	A '38	June 16, '49	A	Sept. '49, p. 820
Stubbs, Walter W.	A '26	Apr. 12, '49	M	July '49, p. 638
Thorpe, John E. S.	A '06	Feb. 24, '50	M	May '50, p. 472
Tracy, Joseph H.	A '08	Mar. 15, '49	M	June '49, p. 553
Val Davies, Arthur E.	A '21	July 6, '49	A	Oct. '49, p. 903
Vaughan, Eleazer A.	M '22	July 10, '49	M	Oct. '49, p. 904
Wallace, Ross S.	A '44	Aug. 28, '49	A	Nov. '49, p. 1009
Walsh, Frank	A '26	Jan. 27, '50	M	Mar. '50, p. 282
Ware, John S.	M '21	Apr. 23, '49	F	July '49, p. 638
Washington, Lee S.	A '19	Apr. 9, '49	A	Aug. '49, p. 708
Watson, Frank C.	M '23	Sept. 2, '49	M	Nov. '49, p. 1009
Woods, Joseph E.	M '48	Sept. 18, '49	M	Dec. '49, p. 1108
Woodward, Clifford D.	A '09	Oct. 26, '49	A	Jan. '50, p. 88
Wotherspoon, Henry H.	A '28	Apr. 5, '49	M	July '49, p. 638
Yarnall, Joseph H.	M '19	June 5, '49	F	Sept. '49, p. 820
Young, James W.	A '03	Feb. 1, '50	M	Mar. '50, p. 282
Zimmer, Albert R.	A '12	Nov. 11, '49	M	Feb. '50, p. 177

1950 is shown in Table VII, together with the number of pages published in preceding years for ready comparison.

Electrical Engineering. Efforts have been made to keep the quality of publication on a high standard by not republishing material which has been published previously elsewhere. In Table VIII, a classification of articles in seven broad fields is presented. The tabulation shows a substantial increase in the number of general interest articles, as well as the number of communication articles. In the future, attempts will be made to increase the number of articles in the fields of industry and general applications to bring these fields more nearly in proportion to the interests of the members.

The practice of publishing a series of essays by well-known authorities, which present a statement of a problem one month, followed by the solution the succeeding month, has met with popular response. The activity has met with favor particularly in the field of education.

The circulation of *Electrical Engineering* has steadily increased with the growth in membership and number of Student members with an all-time high of 58,000 copies of the December issue and an average circulation of 53,825 copies for the year 1949, as compared with 47,800 copies for the year 1948.

Advertising. The number of pages of advertising is about the same as it was a year ago. By the end of the appropriation year, the gross revenue and the net revenue will be larger than they were for the preceding year because all contracts will have been in effect for the entire year at the increased rates which became effective February 1, 1948.

Transactions. Volume 68 of the 1949 *Transactions* has been made available in two parts. Part 1, which contains the papers presented during the first half of the year consisting of 800 pages, was made available for distribution November 15. Part 2, including the papers which were presented during the last half of the year, the Board of Directors' Report, and a complete index comprising 644 pages, was made available for distribution on March 27. This is a month and two months sooner than the corresponding parts were made available for the previous year.

AIEE Proceedings. During the year there has been a substantial increase in the number of *Proceedings* papers ordered and distributed. A total of 7,709 orders were received as compared with 6,295 orders during the preceding year. This represents a 22½-per cent increase in the total number of orders received and represents a distribution of 55,826 copies of papers. When it is considered that there were 202 papers available this year as compared with 247 during the preceding year, the percentage increase on the basis of the number of orders received per paper is even greater, or 47.6-per cent. The increase is attributed to the publication of a reference on the cover of *Electrical Engineering* to the location of the *Proceedings* order form in the advertising section. Most of the copies ordered are for the 10-per cent free allowance and the total receipts were $945.70 as compared with $644.00 during the preceding year.

The *Proceedings* are an interim service to members and Student members only who fill out order forms published in *Electrical Engineering* every few months. In the case of members, there is a 10-per cent free allowance; but in the case of Student members, there is no free allowance.

Table VII. Numbers of Pages of Published Material

Year	Electrical Engineering: Technical Articles	News	Transactions Sections	Transactions Only: Technical Papers	Discussions	Total
1941	337	281	600	542	268	2,028
1944	246	214	738	493	231	1,922
1945	255	225	736	121	143	1,480
1946	285	315	832	254	120	1,806
1947	806	474		1,600*	153*	3,033
1948	832	395		1,643†	172†	3,042
1949	796	320		1,275‡	167‡	2,558

* Preprinted in 227 sections of *AIEE Proceedings*, except for a 17-page technical paper in *Electrical Engineering*.
† Preprinted in 247 sections of *AIEE Proceedings* requiring a total of 2,090 pages.
‡ Preprinted in 202 sections of *AIEE Proceedings* requiring a total of 1,795 pages.

Table VIII. Classification of Articles in Electrical Engineering in Seven Broad Fields

	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	April	Total
General interest	1		1	2	2	3	2	2	1	2	4	2	22
Educational	1	1	1	1			1	1	1	1	1		9
Science and electronics	2	2	1	1	1	1	4	3	3	2	2	3	25
Communication	3	2	1	1	2	1	1	2		3	3	1	20
Power	2	2	1	2	2	3	3	1	2	3	3	4	28
Industry			3	1	1		1	1		1		2	10
General applications		1	2			1	1						5
	9	8	10	8	8	9	13	10	7	12	13	12	119

Special Publications. During the year, the following ten special publications have been made available and ten more are in prospect. The editorial staff has been enlarged to handle the increased number of these publications. They fill a specialized need and some are used for educational purposes. The special publications are on a self-supporting basis and they are made available to members at cost and in general to nonmembers at double cost through order forms published in *Electrical Engineering* from time to time. In the future, sale prices are to include the cost of editorial time.

1. Electric Arc Resistance Welding* (5/49).
2. Mathematics for Engineers (7/49).
3. Industrial Application of Electron Tubes* (9/49).
4. Interior Wiring Design for Commercial Buildings (10/49).
5. Automatic Contouring Control of Machine Tools (10/49).
6. Electrical Engineering Problems in the Rubber and Plastics Industries* (12/49).
7. Bibliography on Rotating Machinery (1/50).
8. Symposium on Electrical Properties of Semiconductors and the Transistor (1/50).
9. Bibliography on Electronic Power Converters (1/50).
10. Electronic Instrumentation in Nucleonics and Medicine* (4/50).

Advance Copies of Papers. The practice of making technical papers approved for presentation at meetings available in advance copy pamphlet form by a photolithographic process has been continued. The few of the papers which are not of permanent record value have been made available as miscellaneous papers known as (ACO) "Advance Copy Only." Advance copies of papers are intended primarily for discussion purposes with a free allowance of ten copies to authors and 50 copies to the sponsoring committee. The other copies are sold to members at a price of 30 cents each and to nonmembers at a price of 60 cents each. The activity is nearly on a self-supporting basis.

* AIEE Conference Report.

Cumulative Index, 1939–1949. Work is well under way on an 11-year cumulative index to the *Transactions*, thus completing the series of cumulative indexes to the *Transactions* since the founding of the Institute in 1884. The index is expected to be made available the latter part of June or early in the summer and it is estimated that it will sell at a price of $2.50 per copy.

Special Subcommittee. A Special Subcommittee has been appointed to consider publication policy in relation to the following suggestions received: The view was expressed that the present publication policy was inadequate to command the loyalty of young but brilliant men electrically trained who are doing frontier work in the electrical sciences in the newer phases of electrical engineering closely related to electronics. Another suggestion received was to the effect that the publication policy to publish 1-page digests of all technical papers in *Electrical Engineering* should be abandoned in favor of briefer abstracts of eight or ten lines, to permit more space to be devoted to the treatment of papers in full. These suggestions are being given thorough consideration and study.

COMMITTEE ON PUBLIC RELATIONS

This year has marked the beginning of a strengthened public relations program for the Institute. Following authorization by the Board of Directors of a modest budget for this purpose, the committee on September 1, 1949, engaged the services of Raymond C.

Mayer to serve as Public Relations Counsel. The Mayer organization is thoroughly familiar with Institute affairs, having publicized several Winter General Meetings in New York and prepared the "publicity kit" which was distributed to Section officers in the spring of 1949, and has since been augmented.

It is the aim of the committee and of its counsel to treat the Institute's public relations as a continuing and integrated program rather than as a series of sporadic efforts centered about the Winter General Meeting. So far as is possible, all important Institute meetings are being given complete news coverage on papers, awards, and other items that show any promise of interesting the general public.

For the Fall General Meeting, 72 papers were examined, and 19 press releases issued. The releases were prepared by the Mayer organization and issued in the Cincinnati area through the AIEE publicity chairman. Releases to national periodicals, press services, trade papers, and others are sent out directly from New York. The same procedure was followed for the North Eastern District Meeting and will be continued for the meetings in Pasadena, Baltimore, Oklahoma City, and elsewhere. Institute technical conferences and a number of the Section meetings are also being systematically publicized.

The publicity kit, giving a large amount of instruction and sample material for local use, supplied to Section Chairmen and publicity officers, has been favorably received. New material for the kit is being distributed on a continuing basis; it includes sample radio programs and general instructions for conducting radio and television programs.

At the Winter General Meeting, a fully equipped and well staffed press room was maintained at the Hotel Statler. A large number of newspaper writers and photographers were given assistance, and 54 releases on technical papers and special addresses and awards were issued. At the suggestion of the committee, the general session was held on the opening day. This aroused an immediate interest in the meeting on the part of newspaper men, an interest which continued throughout the week. The committee also assisted in the preparation of a television exhibit which formed an attractive feature of the meeting.

Assistance has been given to several Sections and to other Institute groups confronted with special problems in their local fields or dealing with special areas of work.

In general the year's activities represent considerable progress in carrying forward the public relations policy established by the Board of Directors. The committee thinks this is on the right track and further progress is to be expected. This program will aid materially in promoting adequate recognition of the work of the Institute and of engineers.

COMMITTEE ON REGISTRATION OF ENGINEERS

The committee has continued its efforts to advise the AIEE membership on the problems of registration.

The committee held a meeting at the Winter General Meeting, with practically the entire membership in attendance.

Previously this committee had arranged for the publication of a paper entitled "Registered Professional Engineers," by R. W. Sorensen and A. H. Lovell. This paper appeared in the August 1949 issue of *Electrical Engineering*. This committee has advised the Student Branches and Sections that this paper is available at headquarters for their use, and has further suggested that it be used as a basis for discussion at local meetings.

It is planned to follow the Sorensen–Lovell paper with two other papers, each covering a particular phase of registration. These are to be published in *Electrical Engineering* in the near future. Reprints of these papers will also be made available at Headquarters.

At the request of the committee, the Board of Directors approved the plan of indicating in the Year Book the AIEE members who are registered professional engineers. This will start with the 1950 edition.

COMMITTEE ON RESEARCH

The Committee on Research sponsored jointly with the Committee on Basic Sciences a symposium on dielectrics. Seven speakers presented various phases of the subject very effectively. Attendance at each of the two sessions exceeded 200.

Plans for sponsoring a symposium on a new and interesting subject are now being formulated for the 1951 Winter General Meeting.

SECTIONS COMMITTEE

Section Activities. Two new Sections, Oak Ridge and Northeastern Michigan, were formed, and applications for two more, Sacramento and Saginaw Valley, are pending.

New Subsections were formed as follows: Eastern Shore, Maryland Section; Mobile-Pensacola, Alabama Section; Ridgway, Erie Section; St. Lawrence International, Syracuse Section; Savannah, Georgia Section; Tacoma, Seattle Section; West Michigan, Michigan Section.

The following additional Subsections are pending: Columbus, Ga.; Boise, Idaho; Alaska; Evansville, Ind.; Grand Rapids, Mich.; Sioux City, Iowa; Finley, Ohio; and Youngstown, Ohio.

Section, Subsection, and membership development has been very active and healthy, as noted above and as shown in Table IX.

The Vancouver Section which has been a part of District 10 has been transferred to District 9, but provision has been made for a yearly visit by the Vice-President of District 10.

Prize Award Rules. A revision of the Institute Prize Paper Rules was prepared by a subcommittee of the Sections Committee, and approved by the Board of Directors, and is now in effect.

Meetings of the Sections Committee. A meeting of the Sections Committee was held during the Winter General Meeting. Two meetings are scheduled for Section delegates during the Summer and Pacific General Meeting.

Section Finances. A subcommittee of the Sections Committee, under the chairmanship of G. W. Bower, has made a progress report on its survey and study of the problem of Section finances for the next 5-year period, which indicates that in general the Sections are getting along fairly well with their present allotments, and should be able to get along for the next few years without an increase. This subcommittee will continue the study and co-operate with the Sections in an endeavor to make this possible.

Survey of Membership Opinion on Institute Policies. At the request of M. D. Hooven, Chairman of a special committee appointed by the Board of Directors to obtain the opinion of the members on the Institute's future policy, a very thorough survey was conducted by the Sections. On the basis of some 9,000 votes, the Board of Directors came to the following conclusions:

1. To work continually for the unification of the profession.
2. To recognize the fact that the Institute finds its chief reason for existence in the technical field.
3. To handle questions on nontechnical affairs as necessary, and as they arise, on an emergency basis, until through unification they can be handled on a general professional basis.

Special Activities. A subcommittee has been appointed to revise the present suggested Bylaws for Sections, not only to bring them up to date to incorporate operation of Subsections, but also to emphasize the desirability of training officers by giving them a sequence of positions, and also simplifying the method of nominating candidates so as to obtain the best officer material.

Possible District boundary changes of one or two Districts are also under present consideration.

General Conclusions. The rate of membership growth is probably the best indication of active and effective Section operation. The recent change in the method of contacting graduating students should show a higher percentage of new members from that source. In general, the rate of growth in members for the next year is expected to be even higher than during 1949–50.

STANDARDS COMMITTEE

During the year, a number of steps in reorganizing Standards Committee activities have been accomplished.

The Standards Manual was revised and approved by the Board of Directors; the President of the Canadian National Committee of the International Electrotechnical Commission was made an ex-officio member of the Standards Committee; a liaison representative from Mexico was appointed to the Standards Committee; and a successful and satisfactory year has been enjoyed under the services of the new committee Secretary, J. J. Anderson, Jr., for whom the current year marks the first full year under his very capable surveillance.

In the field of Standards and Codes, the following were completed or revised during the year: AIEE *550*, "Master Test Code for Resistance Measurement"; *C37.1*, "Relays Associated With Electric Power Apparatus"; AIEE *43*, "Recommended Practice for Testing Insulation Resistance of Rotating Machinery"; *C57.15*, "Step Voltage and Induction Voltage Regulators"; a "Recommended Practice for Minimization of Interference From Radio-Frequency Heating Equipment"; AIEE *22*, "Air Switches, Insulator Units, and Bus Supports"; AIEE *51*, "Guiding Principles for Dielectric Tests"; AIEE *18*, "Capacitors"; AIEE *50*, "Automatic Circuit Reclosers for A-C Distribution Systems." The following were submitted to the Standards Committee and have been approved subject

to certain minor revisions which were referred back to their respective committees: AIEE *76*, "Electric Control Apparatus for Land Transportation Vehicles"; "Test Code for Aircraft Circuit Interrupting Devices."

Further action in connection with two other Standards has become necessary. For Standard *C55*, "Capacitors," for which AIEE is sponsor, a new ASA sectional committee is being organized to permit accomplishing adoption of this Standard as an American Standard. For Standard *C62.1*, "Valve and Expulsion-Type Lightning Arresters," Sectional Committee *C62*, for which AIEE is also sponsor, is being reactivated.

Another responsibility delegated to the Standards Committee by the Board of Directors this year is that of appointing representatives to the Electrical Section of the National Fire Protection Association. This step became a logical one since the AIEE interest in the Electrical Section of the NFPA is principally that occasioned by its responsibility for the National Electrical Code.

Co-operating with the ASA in a very appropriate effort to bring magnet wire into one sectional committee of ASA and all other wire—copper and aluminum alike—into one sectional committee, the Standards Committee withdrew AIEE sponsorship of the *C11* Sectional Committee on Hard Drawn Aluminum Conductors, in order that its scope might be combined with the Sectional Committee *H4* on Specifications for Copper Wire in a new sectional committee, *C7*, having for its scope: specifications for metallic conductors made of wire, whether for use in uninsulated form or for subsequent use in making insulated or covered cable.

The AIEE is, of course, represented on both the *C9* and *C7* sectional committees of ASA.

Recognition should be extended to the retirement of a number of AIEE representatives on various ASA sectional committees where noteworthy service had been rendered for many years in behalf of the Institute and the cause of voluntary standardization in the United States.

Special mention should be made noting the retirement of C. A. Powel, Past President of the Institute and Chairman of Standards Co-ordinating Committee Number 2, and of V. M. Montsinger, Chairman of Standards Co-ordinating Committee Number 3, past Chairman of the Standards Committee, and for many years past a most ardent worker in behalf of standardization both within the Institute and in ASA.

UNITED STATES NATIONAL COMMITTEE OF INTERNATIONAL ELECTROTECHNICAL COMMISSION

Dr. H. S. Osborne, Chief Engineer of the American Telephone and Telegraph Company, and heretofore, Senior Vice-President of the United States National Committee of the International Electrotechnical Commission, was elected President of the United States National Committee to succeed the late L. F. Adams. Dr. Osborne began his term of office in May 1949.

The year was an active one for the IEC, meetings of advisory committees being held as follows:

Advisory Committee 1—Nomenclature, Stresa, Italy, June.

Subcommittee 5A of Advisory Committee 5—Turbo-Alternator Sets, Brussels, September.

Advisory Committee 8—Standard Voltages and Currents, Stresa, June.

Advisory Committee 10—Insulating Oils, Stresa, June.

Advisory Committee 17—Switchgear, Stresa, June.

Advisory Committee 22—Electronic Devices, Stresa, June.

A.C. 28—Co-ordination of Insulation, Stresa, June.

A.C. 31—Flameproof Enclosures, Paris, November.

Subcommittee 34A of Advisory Committee 34—Lamps, London, July, and Paris, November.

Experts Preparatory Committee on Subcommittee 34B of Advisory Committee 34—Lamp Caps and Holders, Paris, November.

Advisory Committee 32—Fuses, Paris, May.

Committee of Action, Stresa, June.

Council, Stresa, June.

The group of meetings at Stresa was attended by 168 representatives of 14 countries, including a delegation of six from the United States, headed by Dr. Osborne.

At the meeting of the Council, Dr. Max Schiesser, Managing Director of the Brown-Boveri Company, was elected President of the International Electrotechnical Commission in place of E. M. Uytborck of Belgium, whose term had expired. Also at the Council meeting the revision of the Statutes and Rules of Procedure, which had been worked on for several years, was approved and declared in effect as of June 1949. These statutes and rules of procedure bring up to date fundamental documents of the IEC so that they should be a better guide to the orderly and systematic conduct of the work. At the meeting of the Council, attention was also given to the finances of the IEC by a Subcommittee on Finances which came to agreements which should place the finances on a sounder basis.

Technical progress was made in the committees which met during the year. A "Recommendation on Lamp Caps and Holders Together With Gauges for the Control of Interchangeability of Lamps" is approaching completion as an international recommendation.

During 1949, the United States National Committee initiated a review of all of the 35 technical projects of the IEC to determine whether or not those in the United States who are most directly concerned with the subject matter of each project are interested in continued participation of the United States in the work. In the past, the USNC has been represented on all these committees. In the review thus far, it has been decided that the USNC will continue participation in 20 projects, and discontinue participation in two projects. It is also concluded that the United States should relinquish one secretariat, though keeping membership on the committee. Thirteen projects remain to be studied to arrive at a decision on continued participation.

A group of 13 technical committee meetings and the Committee of Action will be held in Paris and London in July 1950. These meetings are as follows:

Advisory Committee 3—Graphical Symbols, Paris, July.

Advisory Committee 5—Steam Turbines, London, July.

Advisory Committee 12—Radio Communication, Paris, July.

Advisory Committee 17—Switchgear, Paris, July.

Advisory Committee 23—Electrical Accessories, Paris, July.

Advisory Committee 24—Electric and Magnetic Magnitudes, and Units, Paris, July.

Advisory Committee 25—Letter Symbols, Paris, July.

Advisory Committee 28—Co-ordination of Insulation, Paris, July.

Advisory Committee 32—Fuses, Paris, July.

Advisory Committee 33—Power Capacitors, Paris, July.

Advisory Committee 34A—Lamps, Paris, July.

Advisory Committee 35—Dry Cells and Batteries, Paris, July.

Committee of Action, Paris, July.

International Special Committee on Radio Interference (CISPR), July.

A strong delegation of American representatives will attend this group of meetings.

The work of the IEC continues to expand in scope and in interest to the electrical industry in the United States.

UNITED STATES NATIONAL COMMITTEE OF THE INTERNATIONAL COMMISSION OF ILLUMINATION

The ICI is an international organization of those interested in illumination. It is composed of national committees, representing most of the important countries of the world. Each nation may organize its own committee in any way that it sees fit, so long as it is truly representative of the country. The United States National Committee consists of some 40 persons from the following groups:

AIEE
Association of Edison Illuminating Companies
Illuminating Engineering Society
Optical Society of America
Society of Automotive Engineers
Society of Motion Picture Engineers
Members at large
Delegates to previous conventions

Most of the work of the ICI is carried on through some 25 committees to which the national committee appoints a representative. So far as possible, the work of these committees is handled by correspondence, and they report at the ICI meetings which are normally held once in three years. The next meeting will be in Stockholm in June 1951. At present, the secretariats for four of these committees are in the United States. They are: Colorimetry; Lighting of Public Ways; Lighting Practice (Interior); and Television Lighting. The United States National Committee also has a representative on each of the other 21 committees, and in addition the committee is also planning to offer four technical papers for the next conference.

At the general meeting held in Paris in 1948, the Central Bureau of the ICI previously located in England was moved to the United States. Carl A. Atherton, Member AIEE, is the Honorary Secretary. There is a fair possibility that the 1954 conference will be held in America. If this does take place, the work of arranging for it will fall largely on the United States National Committee. The attendance at Paris in 1948 consisted of approximately 200 delegates plus guests.

The work of the committees and of the Triennial Conference ICI are deemed to be very worth while, furnishing as they do an opportunity for experts from various countries to exchange data and views, and thereby promote the science and art of illumination. The International Commission on Illumination is the only international lighting organization.

COMMITTEE ON STUDENT BRANCHES

The Committee on Student Branches has studied and recommended to the Committee on Constitution and Bylaws changes in several sections of the Bylaws relating to Student

members, Student Branches and Joint Student Branches, Branch Counselors, the District Committees on Student Activities, and the Committee on Student Branches. The proposed changes are intended to clarify certain points regarding Student membership and to include the Chairmen of the District Committees on Student Activities as appointed members of the Committee on Student Branches, and also adjust the times for nominating and appointing Counselors and electing the Chairmen of the District Committees on Student Activities. The latter will enable the President-elect to appoint the members of the Committee on Student Branches at the same time other committee appointments are made. The proposal regarding the membership of the committee was approved in principle by the Board of Directors on June 23, 1949.

A subcommittee of the Committee on Student Branches has investigated the desirability of making an annual Branch award for outstanding student activity and has made the following recommendations:

1. That the AIEE make available a certificate of award to be given annually to one member of each Student Branch.

2. The certificate shall be awarded to the Branch member who has demonstrated the most outstanding Branch activities, particularly in the preparation or presentation of Branch, Section, or District papers, but with due consideration given to committee work, news publications of the Branch, co-operation with local Section, and so forth.

3. The recipient shall be selected by a committee of three consisting of the Counselor of the Branch and two Branch members appointed by the Chairman of the Branch.

4. The certificate shall be signed by national officers only—the President and the Secretary.

The committee recommended that the report be accepted as a progress report, and circulated to the full Committee on Student Branches for study and comments. Action will be taken on the subcommittee's recommendation at the June meeting of the committee.

With the authorization of the Board of Directors, the Chairman participated in two meetings of an "Inter-Society Conference on Engineering Student Chapters" on September 12, 1949, and January 27, 1950. These conferences were sponsored by the American Society of Civil Engineers, and were participated in by the following societies: American Road Builders' Association, American Institute of Chemical Engineers, AIEE, American Institute of Mining and Metallurgical Engineers, American Society of Civil Engineers, American Society for Engineering Education, American Society of Mechanical Engineers, National Society of Professional Engineers, and Society of Automotive Engineers. The purpose of these conferences was to obtain an exchange of ideas and views regarding the operation and objectives of Student Branches and Chapters. The first meeting was exploratory, and the second meeting took the action and made the recommendations that follow:

Action Taken

Recommendations of this conference upon release shall be referred to the respective societies for consideration by their committees on student activities or student chapters.

Recommendations of this conference shall be presented to the Engineers' Joint Council for the information of the Committee on Unity of the Engineering Profession, with the request that a new committee of EJC be set up for special consideration of problems of student organization.

Table IX. Section and Branch Statistics

	For Fiscal Year Ending April 30					
	1945	1946	1947	1948	1949	1950
Sections						
Number of Sections	73	75	75	81	84	87
Number of meetings held	884	1,210	1,333	1,340	1,561	1,605
Total attendance	96,346	113,531	155,649	109,637	128,025	135,847
Branches						
Number of Branches	125	125	126	127	129	130
Number of meetings held	547	716	1,018	1,172	1,350	1,298
Total attendance	17,132	22,844	40,669	77,040	103,828	80,672

Recommendations Agreed Upon

1. That student engineering organizations should be utilized to promote unity and professional consciousness among the students.

2. That at each college which does not have some organized co-ordination of engineering student groups there be formed a council or local society to advise and co-ordinate such groups.

3. That new engineering student activities be carried on by expansion and co-ordination within existing groups so far as practicable.

4. That there be prepared a set of general recommended principles regarding operation of engineering student societies for the guidance of college administrators.

5. That there be formulated a program of typical desirable activities for student engineering groups.

6. That student members of all approved student engineering groups be considered eligible upon graduation for membership in the national engineering organizations, without payment of an admission fee.

The report of the surveys of Student Branch membership as a function of maximum potential membership in each school has been transmitted to the Counselors of all Branches for their information and guidance. This report was prepared by the joint subcommittee of the Membership, Sections, and Student Branches Committees organized last year.

The committee held two meetings, one in Swampscott, Mass., on June 20, 1949, and the other in New York, N. Y., on January 30, 1950.

The Student Branches now number 130, of which 30 are Joint Branches with the Institute of Radio Engineers. The Student membership as of March 27, 1950, was 20,050.

TECHNICAL PROGRAM COMMITTEE

Technical activity in the AIEE, as evidenced by the presentation and publication of technical papers, has continued at a very high level, just under the record set by the previous year. This intense activity has occasioned some congestion, especially at the Winter General Meeting, where there were 58 technical sessions. There has also been a considerable increase in conference-type papers.

The Technical Program Committee has adopted a plan of operation through an Executive Committee composed of the Division Advisors and the appointed members of the Technical Program Committee. This Executive Committee is giving careful consideration to the trend toward conference papers and crowding at some general meetings. It is hoped that a better distribution of technical papers and sessions among the general meetings may be attained.

The effort to plan the program activities on an annual basis has succeeded very well through the co-operation of the technical committee chairmen and the Division Advisors. The preliminary estimates of sessions and papers have been surprisingly accurate, and are very helpful in guiding the Technical Program Committee.

Table X gives a summary of the programs for the year.

COMMITTEE ON TRANSFERS

Activities of the past two years have culminated this year in the preparation of an Operations Guide called "Transfers" and a Publicity Pamphlet entitled "Why Transfer?," both for use by Section Committees on Transfers. As of April 30, these pamphlets were in the final draft form ready for submission to the Board of Examiners and the Board of Directors for approval, following which they will be published.

The recommended Operations Guide officially presents a new conception of Section transfers work, including the development of uniform methods of procedure for guidance of the Section committees. The Publicity Pamphlet as recommended presents reasons why advancement to the higher grades should be of interest to members.

A report on results of the questionnaire sent to Section Committees on Transfers under date of March 18, 1949, consolidated with returns from the questionnaire dated March 22, 1948, was presented to the Committee on Transfers at its meeting in Swampscott, Mass., on June 22, 1949.

The main purpose of issuing the 1949 questionnaire was: to secure information for use in developing a manual of recommended

Table X. Number of Papers Presented During the Year Ending April 30, 1950

Meeting	District	Advance Copy Only	Conference Papers	Transactions	Total	Attendance
Summer, Swampscott		10	60	63	133	1,650
Pacific, San Francisco		10	36	17	63	878
Fall, Cincinnati		22	52	50	124	1,045
Winter, New York		14	137	92	243	3,218
North Eastern, Providence	18	2		14	34	502
Total	18	58	285	236	597	7,293

over-all transfers procedure; to reveal the present extent and nature of Section transfers activities throughout the Institute.

Replies to the 1949 questionnaire were received from 57 per cent of the Sections, representing 56 per cent of the total Institute membership. This volume compares with 33 per cent of returns in reply to the 1948 questionnaire; an increase of 73 per cent which it would seem is indicative of a substantially increased interest in transfers work throughout the Institute. A total of 53 Sections out of 84 (63 per cent) were heard from in reply to the 1948–49 questionnaires. Results submitted would therefore appear to be reliably representative of conditions throughout the Institute.

The questionnaire returns revealed the following information:

1. As of June 1949, 62 per cent of all Sections were engaged in transfers work.

2. Section committees used 16 different names for their respective committees. It has since been recommended, for purposes of uniformity, that all Section committees use the same name as the Institute committee, namely, "Committee on Transfers."

3. Of all Sections reporting, 43 per cent have standing Committees on Transfers, as compared with 57 per cent which do not. However, there does appear to be progress in amending Section Bylaws to provide for Committees on Transfers as standing committees, as initially recommended by the Committee on Transfers in its letter of December 30, 1946, to all Sections. It is hoped that all Sections will adopt this recommendation.

4. In the 48 Sections reporting, 216 members are in transfers work. The average number of Section members per committee men was found to be 72.

5. Regarding methods and policy used in handling transfers work, about 40 per cent of the Sections reporting appear to follow a procedure approaching that recommended in the 1946 letter to all Sections from the Institute Committee on Transfers characterized by complete coverage of Section membership; about 40 per cent engaged in moderate activities on transfers work by various methods; about 20 per cent engaged in little or no transfers activities.

6. About 75 per cent of all Sections apparently are afflicted with a condition of apathy relative to attaining higher grades of membership. How can AIEE grades be held in esteem by those outside the Institute if those within regard them so disinterestedly? Correction of this unhealthy condition is the aim of the method proposed in the Operations Guide.

7. When the Sections were asked for reasons for the foregoing conditions, the majority opinion was that the higher grades did not involve sufficient recognition benefit to induce members to seek advancement. The Publicity Pamphlet "Why Transfer?" and publicity in *Electrical Engineering* are expected to clear this point.

8. When asked how the apathy situation could best be corrected, the majority of replies confirmed the opinion of the Institute Committee on Transfers that the condition can best be overcome through encouragement of the Section committees by: provision of a manual of transfer procedure; and encouraging and assisting in publicizing the significance and advantages of the higher grades.

9. Many suggestions and criticisms were received concerning the over-all subject of transfers. These comments were reviewed and discussed at the June meeting in Swampscott, Mass.

The committee met a second time at the Winter General Meeting. Most of the time at this meeting was spent reviewing the first draft of the Operations Guide.

At the Winter General Meeting, the Chairman of the Committee on Transfers, by invitation, spoke at meetings of the Sections Committee on January 31, and the Membership Committee on February 1. The belief was expressed at these meetings that a milestone in AIEE progress is being reached through introduction of the Board of Review method of Section transfers work; that, when this system has been adopted by the majority of the Sections, rapid progress can be made toward the objective: "Each Member in the Highest Grade for Which He Is Qualified"; that when this objective is reached or closely approached the professional strength, prestige, and vitality of AIEE will have been greatly improved. It was pointed out that a situation such as presently exists with only 32 per cent of the membership in the directly professional grade (Member and Fellow) is not healthy. What this percentage would be if all members were in the highest grades for which qualified is not known, but it is believed that it would be in the neighborhood of 50 per cent.

Other projects completed by the Committee on Transfers during the subject fiscal year are as follows: outline of a publicity article for publication in *Electrical Engineering*; headquarters contacted relative to improvement of Year Book data and prompt notification of approved transfers; Committee on Constitution and Bylaws requested to amend Section 86 of the Bylaws to give the Committee on Transfers representation on District Executive Committees similar to the representation of the Membership Committee, as approved by the Committee on Transfers at its meeting on February 2, 1949; recommendations prepared for improvement of "Proposal" and "Application for Transfer" forms.

On April 7, 1950, a letter was sent to all Chairmen of Section Committees on Transfers outlining to them results of the 1949 questionnaire, informing them of the status of the proposed Operations Guide and Publicity Pamphlet, requesting a report on their transfer activities for the year ending May 13, 1950, and asking their opinion relative to the present requirement of five signers of the "Proposal for Fellow" form number 216 as compared with the former requirement of five Fellow or Member signers.

It is the considered opinion of the Committee on Transfers that the interest and activities of the Sections in this work was greater during the past year than in any other year.

Technical Committees

Co-ordinating Committees

COMMUNICATION, GENERAL APPLICATIONS, INDUSTRY, POWER, SCIENCE AND ELECTRONICS

It has been unnecessary to change the organization or scope of any technical committee. Some problems of overlapping jurisdiction have arisen, but these have been settled within the co-ordinating committees.

A difference of opinion exists on the matter of administrative jurisdiction of joint subcommittees. An opinion poll is under way, which will serve as the basis of action during the next administrative year.

The Communication Co-ordinating Committee, after functioning for one year, and based on the experience during that year, has recommended that the Committee on Aural Broadcasting Systems and the Committee on Television Broadcasting Systems be consolidated to form a new committee to be known as "Committee on Television and Aural Broadcasting Systems." The scope will be established before the end of the current administrative year.

With expansion of technical activities, it is desirable that the members of the Institute be kept informed of the programs of the various technical committees, their scopes, and general organization. This has been accomplished by continuation of the policy instituted last year of devoting a section in *Electrical Engineering* to news items concerning current activities of the technical committees. In addition, the 1949 Year Book for the first time includes a complete publication of organization and scopes for technical committees, subcommittees, joint subcommittees, and working, or project, committees. This information also will be included in future issues of the Year Book as a permanent policy.

In recognition of the fact that the title of the Committee on Servomechanisms does not properly define the scope of this committee, the Board of Directors approved the change in designation to "Committee on Feedback Control Systems."

The Board of Directors has approved the following changes, effective as of August 1, 1950:

1. Change in name of "Co-ordinating Committee" to "Division Advisory Committee."

2. Designation of the Chairman of the Division Advisory Committee as "Division Advisor."

3. Appointment of a new standing committee of ten members to be called "Technical Advisory Committee," which will replace the present Technical Activities Subcommittee of the Committee on Planning and Co-ordination.

4. Membership of the new Technical Advisory Committee to consist of the five Division Advisors, formerly called Co-ordinating Committee Chairmen, namely,

(*a*). Communication Division Advisor.
(*b*). General Applications Division Advisor.
(*c*). Industry Division Advisor.
(*d*). Power Division Advisor.
(*e*). Science and Electronics Division Advisor.

and

Chairman of the Technical Program Committee.
Chairman of the Standards Committee.
Three members-at-large to be appointed by the President, one of whom to be designated chairman of the committee.

5. The scope of the new Technical Advisory Committee is "to stimulate, promote, and encourage technical activities and specifically to be concerned with:

(*a*). All scopes of technical committees.
(*b*). Special events which may involve committees in more than one Division, such as special technical conferences, symposia, and general procedure.
(*c*). Joint subcommittees and other technical committee organization.
(*d*). Assistance to the Technical Program Committee, the Standards Committee, and the Committee on Planning and Co-ordination, when solicited.
(*e*). Consideration of problems brought up by any Technical Division."

6. The Chairman of the Technical Advisory Committee to be a member of the Committee on Planning and Co-ordination.

7. The several Division Advisors no longer to be members of the Committee on Planning and Co-ordination, or Committee on Award of Institute Prizes.

After the approval of the foregoing items, the Board of Directors voted to eliminate from the Bylaws provisions for ex officio memberships of committees.

The foregoing changes give recognition to the previously stated policy that the grouping of technical committees into Divisions, formerly Co-ordinating Committees, does not deprive the chairman of a technical committee of any prerogatives which he had prior to such grouping; the success of the Institute technical activities will continue to depend upon the degree of voluntary co-operation by each technical committee chairman; the Division Advisor will represent the committees within his Division; the creation

of a Technical Advisory Committee will provide the long-needed medium for the exchange of views among Division Representatives and the formulation of recommendations relating to technical committee activities.

During the year, a manual of instructions for technical committee chairmen was completed, and it will be distributed to incoming chairmen. It is intended as a source of information to new chairmen for their general guidance in the performance of their duties.

Technical conferences on specialized subjects continued in popularity during the year, as evidenced by the large attendance at each conference. The success of these conferences is due in part to the willingness of local Sections to act as sponsoring hosts and to arrange for the necessary meeting facilities and publicity. Some technical committees are now sponsoring annual and semiannual conferences under a continuing program. Conferences are scheduled also with societies outside of the Institute—Instrument Society of America, Institute of Radio Engineers, National Telemetering Forum, Radio Manufacturers Association, and so forth. Reports on the conferences held during the past year are given under the heading "Special Technical Conferences."

Technical activities in general continued at a strong pace during the year, taxing the facilities available for parallel sessions during the general meetings. The problem of accommodating the number of papers requiring preprinting and publication in *Transactions* was not too great, due to the combining of the 1950 Summer and Pacific General Meetings, and the co-operation of committee chairmen in estimating their requirements at least one year in advance. Although these matters are primarily the responsibility of the Technical Program Committee, successful operation must depend upon the cooperation of the individual technical committee chairmen, which has been accomplished through the assistance of the Division Advisors.

Communication Group

COMMITTEE ON AURAL BROADCASTING SYSTEMS

The activities of this committee were devoted to the procurement and review of technical papers, and minor participation in review of several Standards referred to it by the Standards Committee. The committee covers a field that is relatively stabilized and at present inactive because of the shift of interest to television. Therefore, on August 1, this committee and the Committee on Television Broadcasting Systems will be combined, and the new committee will be known as "Committee on Television and Aural Broadcasting Systems." During the year, the committee furnished, upon request, some material on the outstanding developments in the field of aural broadcasting for inclusion in an article for *Electrical Engineering*.

COMMITTEE ON COMMUNICATION SWITCHING SYSTEMS

The committee held one well-attended meeting in New York on September 15, 1949, for the purpose of discussing committee work plans for the year. At this meeting, specific papers to be sponsored for the Winter General Meeting were discussed and plans for this meeting were crystallized. Also, tentative plans for the next two general meetings were discussed.

The committee sponsored three formal papers at the Winter General Meeting. The session was well-attended, and each of these papers was followed by stimulating discussion.

The committee is sponsoring three papers at the Summer and Pacific General Meeting. The papers chosen are on closely related subjects, and are particularly appropriate for this meeting, since they are concerned with telephone switching equipment now in service on the Pacific Coast in both Bell and independent operating companies.

Special consideration has been given to plans for the Fall General Meeting, in view of the expressed need to build up interest in this meeting. The committee considered that, while this location is not best suited for papers on the large city switching systems, it would be quite an appropriate location for a symposium of papers on the small community dial office systems. Also, the committee thought it very desirable to obtain participation by both Bell System and independent fields in the meeting.

COMMITTEE ON RADIO COMMUNICATION SYSTEMS

This committee held one formal meeting, on February 1, 1950. Most of the committee activities were conducted by mail and by telephone. The chairman of the committee attended several meetings of the Technical Program Committee.

The committee reviewed a number of technical papers, most of which have been presented at AIEE meetings and some recommended for publication. This effort is being continued to arrange for papers for presentation at future meetings. The committee is co-operating with the Committee on Carrier Current in arranging for the presentation of papers concerning the use of microwave radio equipment for relaying, telemetering, and supervisory control for electric power distribution systems.

The committee sponsored one session with three papers at the Fall General Meeting, and two sessions with six papers at the Winter General Meeting.

The Mobile Radio Subcommittee has undertaken the study of the protection of base stations in mobile radio service against damage by lightning, in co-operation with certain members of the Lightning and Insulator Subcommittee.

COMMITTEE ON SPECIAL COMMUNICATION APPLICATIONS

During the past year, the committee held one full committee meeting and sponsored one technical session. This committee's work is largely devoted to subjects which do not logically fall within the scope of the other communication committees.

A full technical session was sponsored at the Fall General Meeting, on railroad communication, which proved to be of considerable interest. Much of the work in arranging this session had been done by the committee when it was a subcommittee of the Committee on Communication.

In expanding to full committee status, some members were added to the original subcommittee, and it is expected some growth will occur in the first few terms of the committee. At the meeting held during the Winter General Meeting, much time was devoted to searching for areas that are not covered by the other committees. Three subcommittees have been organized, and they are endeavoring to find sources of technical papers on subjects of train control, centralized traffic control, caboose power supplies, communication, and train entertainment. In the field of electroacoustics, material on public address systems and recording schemes are highlighted as the most logical for investigation. The Subcommittee on Special Activities expects to get into the subjects of ceramics, ferrites, and materials with high dielectric constants.

COMMITTEE ON TELEGRAPH SYSTEMS

One meeting of the entire committee was held during the year, at the Winter General Meeting. The committee reviewed its program in furtherance of which it had presented a paper on an electronic regenerative repeater and one on a submarine cable carrier at the Winter General Meeting. There was consensus of opinion that the application of electronic distributors to multiplex telegraph and radiotelegraph circuits is of interest to the profession, and that a symposium of papers should be developed for the Fall General Meeting. Subsequent developments have thrown doubt upon the advisability of presenting such a symposium where the prospective audience would be too small to support the papers with adequate discussion, there being a considerable concentration of telegraph engineers in New York and Chicago.

There was also consensus of opinion that a comprehensive paper on American and possibly foreign telegraph printers should be developed. Substitution of aluminum for copper in certain line applications also will be watched for developments. In the submarine cable field, it is expected that submerged repeaters will soon command attention.

The Subcommittee on Facsimile reported on the conference session on its subject held at the Winter General Meeting. The conference itself proved to be an attraction to every segment of the facsimile industry. Particularly stimulating was an address by the officer heading the Armed Forces' development and procurement activities, who emphasized the essential nature of facsimile to military operations and the unity of effort now being applied to the solution of outstanding problems.

COMMITTEE ON TELEVISION BROADCASTING SYSTEMS

This committee was newly formed this year, and devoted all of its activity to initiation of technical programs, solicitation and review of timely papers, and the conduct of sponsored sessions. The field of activity is divided between transmission systems and receiving systems, each being covered by a separate subcommittee. During the year, the committee sponsored two complete technical sessions, at which eight papers of interest to the membership in the field of television were presented. One of these sessions was at the Fall General Meeting; the other at the Winter General Meeting.

While no specific standardizing activities were undertaken during this first year of the committee, a number of proposals before the Standards Committee were reviewed and comments submitted, where necessary. A

brief statement on television developments in 1949 was prepared for publication in *Electrical Engineering.* Particular effort is being directed toward obtaining papers on the more general aspects of television systems which are of interest to the over-all membership, and effort is being directed toward arranging for additional sessions at future meetings.

COMMITTEE ON WIRE COMMUNICATION SYSTEMS

This committee was formed as a full committee at the time the Communication Group was split from the Communication and Science Group. Meetings were held in September 1949 and in February 1950. One serious problem faced by this committee is that the members are so widely spaced geographically it is very rare for some of them to be able to attend meetings held in the East. Such wide geographical spacing is desirable, of course, to cover the field as thoroughly as possible. To alleviate this situation, it is proposed to hold committee meetings at all general meetings so that each member will be able to attend at least some meetings. This procedure should stimulate interest, make new members available, and, perhaps, increase the number of papers from the western part of the country.

A complete session was sponsored at the Fall General Meeting. A joint session at the Winter General Meeting was sponsored with the Committee on Telegraph Systems. A joint session at the Summer and Pacific General Meeting is planned, and a complete session is planned for the Fall General Meeting. Some papers are already scheduled for the Winter General Meeting and for the 1951 Summer General Meeting.

General Applications Group

COMMITTEE ON AIR TRANSPORTATION

The committee held one meeting of the entire committee, in San Francisco, on August 22, preceding the Pacific General Meeting. Approval was voiced of the plan to concentrate technical sessions at one principal meeting during the year, alternating between the eastern and western sections of the country. It was further decided that areas in which aircraft activities are located should be chosen for the meetings. In view of this, the committee decided to concentrate on technical papers to be presented at the Middle Eastern District Meeting, Baltimore, October 3–5, 1950. A meeting of the committee has been scheduled for October 2, in Baltimore.

Aircraft Electric Rotating Machinery Subcommittee. The subcommittee activities have been concentrated on rewriting Test Code No. 800 for reissue. A subcommittee meeting was held in New York on February 2 to review the material on hand. Most of the work has been completed, and it is expected that a draft of the code will be circulated to the committee for review and approval. It is further expected that the revised Test Code No. 800 will be submitted to the Institute during the summer.

Aircraft Electric Control, Protective Devices, and Cable Subcommittee. The "Test Code for Aircraft Interrupting Devices" that was submitted to the Standards Committee in July 1949 was acted on by letter-ballot. As a result of the ballot several criticisms were received that the Standards Committee believed should be considered before publication of the test code. These criticisms were referred to the subcommittee.

A similar Code for Carbon Pile Regulators is in the process of being prepared for submission to the Standards Committee.

Basic Principles of Altitude Rating Subcommittee. This subcommittee has experienced considerable difficulty in obtaining and compiling data on which to base a Standard on the Basic Principles of Altitude Rating of Electric Machinery. It is continuing its efforts to complete present data, and will extend them from 50,000 feet to 60,000 feet and further if practicable.

Aircraft Electric Systems Subcommittee. This committee is engaged in preparing new material for inclusion in the "Report on Aircraft Electric System Guide," AIEE *750,* issued in July 1947. This will be a continual process as data become available for new sections or revision of existing sections.

COMMITTEE ON DOMESTIC AND COMMERCIAL APPLICATIONS

The subject of domestic and commercial applications is one in which general interest by AIEE members is only awakening. It exists, but has been dormant. In the preparation of meetings and technical conferences, it has often been necessary to solicit papers from outside the Institute membership. The time has not arrived where the committee receives many voluntarily submitted papers. Hence, the time factor in arranging a session is vital, and it is difficult to get papers prepared long enough in advance for the usual review. Time and continued committee activity and enthusiasm will help correct this situation. Meanwhile, the need of continuity is evident, as papers may have to be started during one administrative year for presentation during another.

The subject of electric heating of houses, whether by full conversion of electric power input by resistance heating, or by partial conversion of electric power input to extract heat from earth, air, or water by a pump, is of widespread interest not only to home owners, but also to public utilities, and the committee thinks it important to keep the Institute informed on developments in the field by appropriate meetings in the future.

The manufacture of domestic appliances is a substantial segment of American industry. The energy to operate electric appliances in the home makes up a substantial part of the load on power systems. A great deal of high-class engineering is involved in this field. An unusual opportunity exists for service to the people of the nation. It is worth while for the Institute to recognize the magnitude and opportunity of engineering in this area, and to take steps to attract into its membership those who are already active in its engineering phases.

The committee held a meeting in New York, on February 3, at which ten members were in attendance. Notices of the activities of the committee have appeared from time to time in *Electrical Engineering,* in the section devoted to "Committee Activities."

L. R. Emmert has been appointed the committee's delegate to the National Farm Electrification Conference, with L. N. Roberson as alternate.

The committee has organized three subcommittees to carry out its objectives.

Subcommittee on Electric Heating of Houses, and Heat Pumps, for the West Coast. This subcommittee organized and held a special technical conference in its field in Medford, Oreg., on April 12.

Subcommittee on Electric Heating of Houses, and Heat Pumps, for the East. This subcommittee sponsored a session at the Winter General Meeting. Five papers were presented, three on heat pumps, and two on electric resistance heating, and 155 persons attended the session.

Subcommittee on Domestic Appliances. This subcommittee has arranged a special technical conference to be held in Cleveland, Ohio, on June 20, in co-operation with the Cleveland Section.

COMMITTEE ON LAND TRANSPORTATION

This committee has continued to keep in active touch with the developments in the field of electric transportation. The outstanding developments during the past year have been the development of the gas-turbine electric locomotive, and the application of ignitrons to railroad motive power to enable the advantages of high-voltage a-c power transmission to be combined with the advantages of the d-c traction motor for train propulsion. Papers on both of these developments were presented at the Winter General Meeting, and these subjects will be actively followed by further papers and reports. The continuing development and application of diesel-electric motive power has been reported in the form of various papers covering the details of improvement to this type of motive power for the Winter General Meeting, and the 1950 Summer and Pacific General Meeting.

The developments in urban transportation equipment are being followed, and papers are being prepared for presentation at future meetings of the Institute in connection with this particular application. Subcommittee activity continues in connection with the review of AIEE Standards applicable to this committee assignment, and to the continuing collection of data relative to the existing railroad electrification development, both in this country and abroad.

One committee meeting was held in connection with the Winter General Meeting, at which 17 members of the committee were present, and further meetings are planned for during the year as opportunity permits.

COMMITTEE ON PRODUCTION AND APPLICATION OF LIGHT

A very lively conference session on long tube fluorescent lighting was held as a part of the Winter General Meeting. As has been the custom, a meeting of this committee was held at that time. Attendance was unusually good, due to consideration that was being given to a recommendation to Standards Committee on approval of Illuminating Engineering Society "Recommended Practice for Office Lighting" as a possible American Standard.

Discussion of committee activities during the year led to a decision to hold one lighting session each year, with preference being given to the Winter General Meeting. A list of possible subjects for next year's session

was suggested. A plea was made for papers on related subjects which might be published in *Electrical Engineering*. Subcommittees were inactive during the year.

COMMITTEE ON MARINE TRANSPORTATION

The committee held one well-attended meeting at Institute headquarters on April 14, 1949. The committee has been working on revisions to "Recommended Practices for Electrical Installation on Shipboard," as issued in December 1948. The committee also has been working on the international standardization of electric installations on shipboard.

Subcommittee Activities. The subcommittees have been quite active, each reviewing the sections of Standard *45* under its cognizance, and making reports to the main committee.

Industry Group

COMMITTEE ON
CHEMICAL, ELECTROCHEMICAL, AND
ELECTROTHERMAL APPLICATIONS

The committee held one session at the Summer General Meeting, and two sessions during the Winter General Meeting.

During the past year, the work has followed the pattern set during the preceding year. In the past year, the Metallic Rectifier Subcommittee was elevated to full committee status in the Institute and removed from the jurisdiction of this committee.

The activity of the subcommittees is outlined in the following:

1. *Arc Furnaces and Electrothermal Processes.* This subcommittee continues to study the problems of arc furnace application. The problems of surging and regulation are again coming to the fore, and are being actively studied. A session is planned for the 1950–51 season.

2. *Electrolytic Processes.* This subcommittee is continuing its work on subcommittee report on influence of cell line characteristics on the selection of electric power and conversion equipment.

3. *Cathodic Protection.* This subcommittee has been inactive during 1949–50, due to the resignation of the chairman and inability to obtain a new chairman. A new chairman has now been appointed, and full activity is expected next year. The committee is planning a session on corrosion.

4. *Petroleum Refining and Production.* This subcommittee has been relatively inactive during the current year. However, activity is planned for the 1950–51 season.

5. *Batteries, Battery Forming and Charging.* This subcommittee has been very active this year. An excellent conference session was sponsored at the Summer General Meeting, and additional meetings are planned for 1950–51. The committee is continuing its work on the inconsistencies in the Storage Battery Standards and is making every effort to have these problems resolved in the near future.

6. *Chemical Industries.* This subcommittee sponsored two sessions at the Winter General Meeting, on the application of power cables in chemical plants. There continues to be great interest in this subject, and further sessions are planned for the next Winter General Meeting to attack the installation problem. The subcommittee is continuing its study of the application of equipment to this industry.

COMMITTEE ON ELECTRIC HEATING

The committee has generally agreed that it will emphasize the Winter General Meeting as a time for general paper presentation, with an investigation going on as to the prospects for a Conference on Electric Heating in the midwest area, similar to the biannual Welding Conference. This plan was decided on at the committee meeting in New York on January 30, 1950. Meanwhile, the work of the subcommittees is going on as follows.

Subcommittee on Induction and Dielectric Heating is co-operating actively with the Federal Communications Commission on reports of radio interference from heating equipment. Members are working on assigned sections of proposed equipment Standards and performance tests. Some sections have been received and are being edited and reviewed. Work on definitions is being co-ordinated with the Institute of Radio Engineers.

Subcommittee on Radiation Measurements Above 200 Megacycles is working actively on preliminary Standards in this field. With several FCC personnel included in its membership, co-operation and field tests are progressing satisfactorily. Various sections are to be submitted at the next meeting for editing and review.

Radiant Heating Subcommittee has been working with the Ovens and Furnaces Committee of the National Fire Protection Association to extend and clarify Standards for electric equipment for Class *A* ovens and furnaces. These proposed Standards presumably will become effective on June 1, 1950. Meetings are continuing to sponsor investigation of controversial questions regarding various sources of infrared radiation.

Subcommittee on Resistance Heating and Electric Furnaces is planning to recommend that its title and scope be limited to resistance heating. A working group is being organized to collect, edit, and disseminate information on various resistance heating applications, probably in a loose-leaf handbook form.

COMMITTEE ON ELECTRIC WELDING

The activities of this committee have been directed toward fostering interest in electric welding, organizing subcommittees for study and research on this subject, and sponsoring a "Special Technical Conference on Electric Welding." A special technical conference was conducted in co-operation with the American Welding Society and the Industrial Electrical Engineers Society in Detroit. The purpose was to bring industrial electrical engineers together in a conference on subjects in which all were primarily interested. The committee plans to hold a similar Electric Welding Conference every other year.

The committee conducted a session during the Winter General Meeting, and held a number of committee meetings during the year for planning its activities, including the work necessary for the conference.

Subcommittee on Power Supply for Resistance Welding is continuing its work on a special report, and, during the February 2 meeting of the main committee, two working groups were recommended for addition to the Power Supply Subcommittee, namely, Working Group on Probability and Working Group on Proposed Protection Devices in Welding. However, during a meeting of the subcommittee, it was decided that this work, because of its nature, should be included with that of the Users Working Group instead of in a separate group. The subcommittee, in order to cover all interests in power supply for welders, has a Users Working Group, a Manufacturers Working Group, and a Utilities Working Group, with each preparing a section of the special report. The special report of this Power Supply Subcommittee should be available in the near future.

Subcommittee on Welding Research was organized during the year. This subcommittee hopes to increase the efficiency and usefulness of the electric arc research by: the interchange of information on past, present, and planned future research activities; the co-ordination of active research projects through mutual co-operation; the definition of basic electric-arc problems which need further study and research; the stimulation of technical papers and sessions on electric arcs; encouraging the education of graduate students for electric-arc research; and bringing the needs and advantages of electric-arc research to the attention of industrial and other potential sponsors for research. It plans to initiate this program by: preparing a reasonably complete bibliography of past research in the field of high-pressure electric arcs; preparing a summary of nonconfidential electric-arc research projects in effect at present; and defining the basic electric arc problems which must be studied now. Should the subcommittee be successful in carrying out the three initial phases outlined, the material it has collected and organized may serve as a basis for significant technical papers and for sessions or conferences on high-pressure electric arcs. Publication of such information and indication of useful research projects for the future might lead to increased interest on the part of industry and other potential sponsors of fundamental research.

COMMITTEE ON FEEDBACK
CONTROL SYSTEMS

Last fall, the committee was formed to take over the duties previously delegated to the Joint Subcommittee on Servomechanisms. While this action necessitated no drastic change in the objectives of the group, the change to full-committee status appreciably enhanced the opportunities for effective operation. The committee had 32 members at the close of the year.

The scope of the committee covers the treatment of matters in which the dominant factors are the terminology, requirements, design, construction, and operation of equipment, and the circuits pertaining to control systems involving feedback, such as servomechanisms, regulators, and governors, excluding measuring and recording instruments. This committee co-operates by means of liaison membership with other technical committees within the Institute interested in servomechanisms, regulators, or other control systems, as well as with related committee work in associated societies.

Participation in two Institute general meetings during the year consisted of the sponsorship of ten papers, of which one was a subcommittee report on terminology. The two prize-paper awards in the Industry Group announced at the Winter General Meeting were for papers sponsored by this committee. At the Summer General Meeting, a joint session was held with the Committee on Industrial Control, and at the Winter General Meeting a joint session with that committee and a session on feedback control were held.

Subcommittee on Terminology and Definitions. Because of the rapid growth of professional activity in the field of feedback control, the problems regarding unified terminology and definitions pertaining to such devices as servomechanisms, regulators, and amplifiers are many. This subcommittee was appointed to work on the subject in co-operation with subcommittees of other Institute technical committees. During the year, three subcommittee meetings were held. At the Winter General Meeting, a conference paper report on the work of this subcommittee in collaboration with similar committees in ASME, ASA, and AIEE was given. Future activity is expected to define basic terms, and prepare a glossary of symbols, terminology, and specifications for performance.

Related Activity. One of the important functions performed by the committee has been to advise the editorial staff of *Electrical Engineering* on the suitability of manuscripts. Formal AIEE activity in the field of feedback control systems has stimulated many manuscripts in this field. Codifying these manuscripts and recommending their allocation either to *Electrical Engineering* or the Technical Program Committee has been a large activity. At the close of this year, a backlog of manuscripts was under review for the *Transactions.*

Future Activity. Consideration has been given to the feasibility of scheduling an AIEE conference on feedback control systems late in 1951.

Because of the wide geographical distribution of the interest in feedback control systems, this committee has appointed subcommittee groups on the West Coast and in the Middle West.

COMMITTEE ON GENERAL INDUSTRY APPLICATIONS

The activities of this committee have been directed toward fostering interest and co-ordinating activities within the various subcommittees, and sponsoring "special technical conferences," where industrial electrical engineers can meet others in the same or allied fields and discuss electrical applications. Industrial processes in a mass production age offer numerous and diversified opportunities for the application of equipment utilizing electric power. The use of electric power in industry has increased 118 per cent (from 79.0 to 171.5 billion kilowatt-hours) in the last ten years (1939 to 1949) and accounts for 57 per cent of all the power used in the United States. Programs of the special technical conference type are ideally suited for discussing problems associated with an industry or a group of related industries.

The committee held two general meetings during the year, one in Cincinnati, in October 1949, and the second in New York, in February 1950. At both of these meetings, plans for future activities were discussed. The committee sponsored a technical session at the Winter General Meeting, on the subject of "Explosion Hazards in Industry and Their Relation to Electrical Installations." A second session on this general theme is being planned for the 1951 Winter General Meeting. A technical session is also being planned for the Fall General Meeting.

The activities of subcommittees covering specific assignments are summarized in the following.

Subcommittee on Machine Tools. This subcommittee organized three sessions on machine tools for the Fall General Meeting. Ten papers discussing machine tool applications and problems were presented at the three sessions, which were well attended. This subcommittee is planning on holding a special technical conference in New England next fall.

Subcommittee on Rubber and Plastics Industry. This group has arranged to hold, jointly with the Akron Section, an annual special technical conference in Akron. The program this year was an all-day session on May 5.

Subcommittee on Textile Industry. A conference was held in Atlanta on April 13 and 14, and a session was held at the North Eastern District Meeting.

Subcommittee on Pulp and Paper Industry. In connection with the West Coast Subcommittee, this group is planning a technical session at the Summer and Pacific General Meeting, the theme being "Lumber and Paper Mills." It will feature papers on the application of electric equipment to saw mills, paper machine drives, and pulp mills.

Subcommittee on Materials Handling. A technical session on factory elevators and hoists is being planned for presentation at the 1951 Winter General Meeting. Freight elevators form a vital part of the material-handling system in multifloor factories, warehouses, garages, and other types of buildings. Each freight elevator installation usually involves a special engineering study, and the session will be of interest to engineers who have the problem of determining elevator requirements and types of equipment for industrial plants.

The subcommittee work discussed does not cover, by any means, all the industries which come within the scope of the committee. One of the problems discussed at the February 2 meeting was the organization of additional subcommittees to cover other industries, such as food processing, and the ceramic and cement industries, where the electrical engineering problems of general interest to these industries may be discussed.

This committee thinks there is no better way to further engineering knowledge and bring the AIEE close to engineers working on industrial problems than to bring together in technical sessions and conferences a group of these engineers. The committee has met with some degree of success in this task. Effort will be made to make the work more effective in the future through a long-term planning program.

COMMITTEE ON INDUSTRIAL CONTROL

The committee held two meetings, and sponsored five technical sessions, three of which were held in conjunction with other committees of the Industry Group. The following projects have been worked on by the various subcommittees.

Subcommittee on Standards has completed work on a proposal to revise the Industrial Control Section of ASA Standard *C42,* "Definition of Electrical Terms," which is sponsored by AIEE. The proposal is now in the hands of ASA Sectional Committee *C42,* to be considered for the final revision of that Standard. Another AIEE sponsored Standard is ASA *Z32.12,* dealing with graphical symbols for electric apparatus. This Standard has been in use for several years, and its acceptance by industry has been very satisfactory in general. However, certain criticisms have been raised in some industries claiming inadequacy of certain symbols. For this reason, the committee has started a study of the basic symbols with the aim of resolving difficulties.

Subcommittee on Electronic Control, through its working groups, has been active in discussing definitions of terms. This work is approaching completion, and it is expected that, during the ensuing year, proposals for definitions will be presented to the proper ASA channels.

Subcommittee on Bibliography has completed the draft of a comprehensive bibliography on industrial control, which includes brief abstracts on all important American and foreign literature on the subject. The final draft of the manuscript is being prepared for printing as an AIEE publication.

Subcommittee on Regulators and Feedback Control Systems has been newly formed. The subcommittee will provide liaison with other committees operating in related fields, and special emphasis is laid on the importance of such systems for industrial applications. The first project of the subcommittee is the development of system classifications and definitions.

COMMITTEE ON INDUSTRIAL POWER SYSTEMS

The committee has been quite active this year, starting with two sessions at the Fall General Meeting, one of which was sponsored jointly with the Committee on Industrial Control. Three committee meetings were held.

On April 19–20, a Power Conference was held in Pittsburgh under the joint sponsorship of the Pittsburgh Section, the Committee on Power Generation, the Committee on Industrial Power Systems, and the Committee on System Engineering. This first Power Conference was very well received, and the sponsoring committees have been strongly urged to present another in the near future.

For the Summer and Pacific General Meeting, the committee is sponsoring a session, jointly with the Committee on Chemical, Electrochemical, and Electrothermal Applications, on problems in the petroleum field.

Subcommittee on Revision of "Electric Power Distribution for Industrial Plants." This subcommittee has been working actively to prepare a revised and improved edition

of the report. This work has not reached the publication state as early as anticipated, but should be ready early next year.

Subcommittee on Wiring Design for Commercial Buildings. This subcommittee prepared its report in published form in time for announcement at the Fall General Meeting. The report contains a wealth of information, including quick-estimating charts and valuable check lists, which will be helpful to anyone interested in the wiring design for large commercial buildings.

COMMITTEE ON MINING AND METAL INDUSTRY

This committee is continuing its program of presenting papers of interest to the electrical engineers in the fields of mining and metal. There are two active subcommittees. The Mining Subcommittee includes members interested in bituminous coal, anthracite coal, potash, copper, and other ores. The Metal Subcommittee includes members in the fields of steel, copper, aluminum, and other nonferrous metals. The committee sponsored two sessions on mining and one session on metal at the Fall General Meeting, and has arranged for two sessions on mining and one session on metal at the Summer and Pacific General Meeting.

The present program of the committee includes the development of Standards, co-operation with the American Mining Congress and the Association of Iron and Steel Engineers, and the sponsoring of sessions which will interest primarily the electrical engineers working for the mining and metal industries. In addition to having many members on the committee who are also members of the Association of Iron and Steel Engineers and the American Mining Congress, the committee has one member each assigned as liaison between it and these organizations. The committee hopes to develop technical conferences which can be scheduled in such locations and at such times that the co-operation of the other two organizations can be obtained.

One item of special interest is that a representative of *Coal Age*, a publication for the mining industry, covered the mining sessions at the Fall General Meeting, and gave a good write-up with favorable publicity for AIEE in an issue immediately following the meeting. Arrangements have been made to have the *Engineering and Mining Journal*, a publication for the hard rock mining industry, cover the two mining sessions at Pasadena in the same manner.

Power Group

COMMITTEE ON CARRIER CURRENT

During the year, the committee held four meetings, and sponsored one conference-type session on microwave applications at the Summer General Meeting. Much of the work is carried on by subcommittees.

Subcommittee for Preparation of a General Interest Paper on Carrier Current is approaching the end of its work, and it is expected to go out of existence.

Subcommittee to Report on Application Guidance for Carrier Current is also completing its assignment, which has been carried on essentially by one man, and will cease to exist.

Subcommittee on Methods of Measurement is checking its report against field observations, and modifying the report from time to time in minor details to promote simpler or more accurate methods of field testing.

Subcommittee on High-Frequency Characteristics of Power Equipment originally planned to carry out factory tests. However, it develops that in most plants this would cause undue interference with the routine of production. It thus appears that such data will be derived from tests of equipment in the field.

Subcommittee on Carrier Current Characteristics of Transmission Lines and Systems has obtained excellent response to some 130 copies of a questionnaire, but unfortunately very little of the information is in such form as to be useful for comparison with other field observations. Up to the present time, field tests were conducted on a random basis, in general, observing only relative values.

Subcommittee on Standard Terminology for Carrier Current has completed its report, and will go out of existence as soon as co-ordination with the Standards Committee is completed.

Subcommittee on Long Life Tubes is assembling information from both manufacturer and user sources, and will draw up a report with recommendations.

Subcommittee on Use of Microwave Equipment for Relaying, Telemetering, and Supervisory Control has been most active. It provided material for a conference session at the Summer General Meeting, and is presently assembling papers for a full technical session at the Summer and Pacific General Meeting.

Subcommittee on Operating Experience With Carrier Current Relaying Channels has sent questionnaires to at least the major users of carrier equipment, and is assembling and tabulating the replies.

Plans for the coming year include a technical session on microwaves and a conference session on carrier current during the Summer and Pacific General Meeting. At the same time, it is planned to call a meeting of the entire committee, and invite all interested parties to attend. The subcommittee seeks an expansion in membership, especially on the West Coast, and plans to establish a West Coast Division, possibly under a second vice-chairman. The general objectives remain about the same, but will be adjusted, as required, to cope with new factors as they arise.

One new element is Federal Communication Commission Docket Number 9288 in which it is proposed to expand the low power rule so that power-line carrier would be specifically included. Many interested organizations are co-operating with the FCC in making field observations. The committee is interested in the academic factors, and will assemble field data from all possible sources to expand knowledge of propagation from practical lines in clear areas, as well as those in which the field will be distorted by foreign objects.

COMMITTEE ON INSULATED CONDUCTORS

Organization. The committee has 48 members and, in addition, 46 special members who serve only on subcommittees. The initial organization of this new committee into 12 subcommittees has continued. This arrangement has facilitated carrying out one of the main reasons for forming this committee, that is, to form avenues for considering all types of projects relating to research, design, installation, and operation of various types of insulated wires and cables.

Committee Meetings. The committee is pursuing the policy of having two meetings during each administrative year. The first is for one day, and is held in the fall in the East (has been New York). The second is for two days, in order to allow ample time for subcommittee meetings and for general informal discussions, and this meeting is held in the Middle West (to be held in Chicago in May this year). The average attendance at the committee meetings has been about 60. In addition, the Administration Subcommittee has had two meetings at the time of AIEE general meetings.

Projects. The subcommittees have over 90 projects under consideration. In addition, informal reports on various items of general interest are being presented at the meetings. The discussions of these projects and of the reports, and the records thereof in the minutes, are helping make the activities of considerable value to the members and special members.

Standards. Recently, the work on revising the definitions for wires and cables was completed and forwarded to the ASA Sectional Committee *C-42* for its use in the revision of "Definitions of Electrical Terms." Work on other Standards and test codes is under way by the committee.

Technical Papers. Twelve papers obtained by the committee were presented at three technical meetings of the AIEE. It is to be noted that a good share of these pertain to subjects such as design of cable accessories, which were not given the attention that they might have had under the AIEE committee organization that obtained several years ago. In addition, a summary of information and conclusions drawn from a survey conducted by the committee on practices relating to protective coverings for lead-sheathed power cables was published in *Electrical Engineering*.

COMMITTEE ON POWER GENERATION

The committee held three meetings during the year, the first at the Summer General Meeting, the second at the Fall General Meeting, and the third at the Winter General Meeting. The activities of the committee, as reported by the various subcommittees, are as follows.

Prime Mover. Preliminary talks with The American Society of Mechanical Engineers representatives have indicated their willingness to discuss the feasibility of setting up Standards for turbines rated at 7,500 kw and smaller.

Station Design. Through the efforts of this subcommittee, a session was organized on "centralized control," at which papers and discussions were presented in favor of and against centralized control. The subcommittee is sponsoring two sessions for the 1951 Winter General Meeting, one on the co-ordination of station design and analysis of plant operating troubles, and another on safety and fire-fighting equipment.

Speed Governing. A session was held at the Fall General Meeting. Specifications for governing of steam turbines 500 kw and up were completed by the joint AIEE-ASME Committee on Speed Governing Specifica-

tions. Progress was made on specifications for hydraulic turbine governors. Work also was started on speed governing specifications for internal combustion engines.

Excitation Systems. This subcommittee completed the revision of definitions of terms relating to excitation. It organized a session for the Winter General Meeting, and is sponsoring a session for the Summer and Pacific General Meeting.

Application of Probability Methods. This subcommittee organized a session for the Fall General Meeting, and sponsored the collection of outage data on high-pressure units and boilers, which are being collected by the Edison Electric Institute and analyzed by the Consolidated Edison Company of New York, Inc. The subcommittee is planning a symposium for the 1951 Winter General Meeting, on the reserve practices of hydroelectric companies. The objective of this symposium is that of divulging these practices and of stimulating the use of probability methods in hydro systems.

Hydroelectric Systems. The activities of this subcommittee during the year covered the study of outstanding developments in the field. Along these lines, the subcommittee is sponsoring a session for the Summer and Pacific General Meeting, which will include papers on underground hydroelectric plants and on factors determining the electrical design of power systems with large hydroelectric stations.

Pacific Coast. This subcommittee held two meetings during the year, one in San Francisco and one in Los Angeles, at which various problems of general interest were discussed.

Other activities of the Committee on Power Generation were:

AIEE Pittsburgh Power Conference was organized jointly with the Committees on Industrial Power Systems and System Engineering for presentation of 18 papers. Subjects ranged from general power-plant administration topics to central-station and industrial-station design and operating problems.

1950 Fall General Meeting. Three sessions are planned for this meeting on the subjects of: supervisory instruments; enclosed motor applications in power plants; gas turbines; and quick-starting of steam turbines.

Economic Evaluation of Alternate Central Station Layouts. This project will be carried by the System Economics Subcommittee as a joint project with the Committee on System Engineering.

COMMITTEE ON PROTECTIVE DEVICES

Three meetings were held by the committee, at which time the subcommittees reported on their activities and reviewed their plans for future work. The activities of the committee are carried on largely by three subcommittees.

Fault Limiting Devices Subcommittee. Application guides covering the grounding of synchronous generating systems, the methods of grounding transmission systems, and the application of ground fault neutralizers were completed during the year. These guides were presented as ACO (advance copy only) papers, and issued on a trial basis with the expectation that they would be reviewed by the AIEE membership. The working groups that prepared these guides are anxious to receive comments from anyone interested in making suggestions for their improvement. Early next year, the working groups will proceed to make final revisions.

The "Bibliography on Resonant Neutral Grounding," containing references to articles on resonant neutral grounding in the American and foreign press, was completed through the year 1938 and presented at the Fall General Meeting by title only. The bibliography covering the period 1938 to 1947 has been assembled and is scheduled for presentation by title only at the Fall General Meeting.

The Working Group on Power System Fault Limitation completed its report on methods of limiting fault currents on expanding systems, and presented it as a conference paper at the Winter General Meeting. After comments have been received, it will be brought up to date and presented formally at an AIEE meeting, and also published in the *Transactions.*

A report entitled "Field Survey of Unbalanced Charging Currents" was presented at the Fall General Meeting. This report covered the results of the survey, and indicated that the requirement that ground fault neutralizers be capable of continuously carrying 30 per cent circulating current is adequate.

One of the projects now under consideration is a survey to determine present grounding practices on industrial systems. This survey will determine if there is any accepted practice or agreement in the connection of the neutral, that is, whether the power system neutral should be grounded through a resistor, a reactor, potential transformer, ground fault neutralizer, or a combination distribution transformer and resistor. This survey will cover plants with independent generating systems as well as those which are tied in with utilities. Later, if the survey indicates that there is a need for an application guide on industrial systems grounding, a suitable group will be organized to prepare this guide. It is expected that this project will be joint with the Committee on Industrial Power Systems.

A report is also being prepared outlining the factors which determine the size and rating of grounding transformers.

Lightning Protective Devices Subcommittee. The activities of the Lightning Protective Devices Subcommittee during the past several years have been directed toward the co-ordination and unification of information relating to: performance characteristics; testing Standards; and applications of various types of lightning protective devices. Formerly, this information was incomplete, contained inconsistencies, and was scattered through several publications.

1. Performance characteristics of various types of lightning protective devices was issued for the first time under one cover in September 1949, AIEE 49-286.

2. The difficult and extensive work, particularly in the co-ordination of fundamental definitions and terminology, carried on by working groups within the subcommittee has resulted in the publication of a new and much-needed combined Protective Devices Standard *28A*, February 1950. The Standard was issued in report form and as a proposed revision to ASA *C-62* to avoid overriding an existing ASA Standard. It will be reviewed by the *C-62* Committee in the revision of the ASA Standard.

3. The subcommittee is now directing its efforts toward the completion of the "Application Guide for Lightning Protection of Substations." This guide, while it is directed particularly to the problems of substation protection, will treat important application problems of a general nature relating to the various types of protective devices. It will supplement the Performance Report and Combined Standards to provide essential lightning protection information in convenient, compact form. The Application Guide is scheduled for publication and presentation at the Fall General Meeting.

The studies which have been under way on recovery voltage characteristics of distribution systems in collaboration with the Committee on Transmission and Distribution are nearing completion. When this information becomes available, the subcommittee will reconsider the recommendation of specific recovery voltage conditions to apply during standard tests. The addition of the recovery voltage data will complete the present Lightning Protective Devices technical information program. The agenda of the subcommittee include new items relating to the protection of aerial cable, dry-type transformers, rod gap characteristics in the short-time region, and evaluation of the effects of rate of rise of surge current with respect to arrester performance.

Co-ordination of Insulation Subcommittee. This subcommittee was set up to deal with problems of insulation co-ordination which come within the scope of the Committee on Protective Devices. To date, its function has been to keep the members of the committee informed on the activities on insulation co-ordination in other Institute and ASA committees which are dealing with this subject. There are no plans for active project groups in this subcommittee at present.

COMMITTEE ON RELAYS

The committee held three meetings, and sponsored three technical sessions, at which 11 technical papers and two conference papers were presented. The technical activities of this committee were carried on through a number of project committees which are appointed to fulfill specific assignments. During the past year, four new project committees were organized. Following are the reports of the various project committees.

Generator Protection. This committee is investigating various methods of generator protection, and expects to publish a report of its findings. In May 1948, a draft of an AIEE Committee Report on Generator Protection was prepared and distributed to members of the project committee for comment. Discussion of the material in this report indicated the need for obtaining more data on present practices, and a decision was made to issue a questionnaire. A draft of the proposed questionnaire was prepared and distributed to the committee members for comment in September 1949. This draft has been revised to include the suggestions that were received, and is about ready to be issued in final form to a representative list of utility companies. The data from the replies will be summarized and used as a basis for preparing the final committee report.

Bibliography of Relay Literature. An interim report has been prepared from the relay papers presented in 1949. It is planned that

another formal report covering the past three years will be available in 1950.

Co-ordination of Construction and Protection of Distribution Circuits. This joint working group of the Committee on Relays, the Distribution Subcommittee, and the Edison Electric Institute Transmission and Distribution Committee is continuing its study of correlation of construction and protection practices on the performance of distribution circuits with regard to number of faults occurring and percentage of faults which are permanent. Thirty-eight operating companies have supplied the working group with information regarding faults on 209 circuits for the year 1949. Items being investigated include effects of type of system, size and covering of wire, configuration and spacing, and insulator and cross brace material on the number of faults occurring; and the effects of speed of clearing of faults on the percentage of faults which become permanent. It is expected that a report will be presented at the 1951 Winter General Meeting.

Standards for Power Relays. This committee completed, in 1949, a proposed revision of the ASA Standard *C-37*, American Standard for Relays Associated With Electric Power Apparatus. The Standard was approved by letter-ballot of the Committee on Relays early in 1949. It was sent to the AIEE Standards Committee in May, and was sent to the ASA *C-37* Committee on August 4. The ASA *C-37* Committee approved the Standard with minor editorial changes. The committee is in the process of gathering material on performance requirements of relays so that on the next revision a section on "Performance Standards" can be added to the existing Standard.

Insulation Levels for Relay and Control Circuits. This project committee completed its work, and a report was presented at the Fall General Meeting. The committee found that a value of 1,500 volts a-c is an adequate test voltage for the current, potential, and trip circuits of relays and associated circuits. An investigation of the standard recommended contact spacings for various types of high-speed relays showed that all of these are adequate to withstand a test of at least 1,500 volts a-c across contacts.

Sensitive Ground Protection. This committee presented its final report in the form of a technical paper at the Winter General Meeting. The report summarizes available methods for sensitive ground protection of 3-wire systems and outlines the limitations of presently available methods for the protection of systems with multigrounded neutrals.

Transmission-Line Protection. This committee sponsored three papers on transmission-line protection at the Winter General Meeting. These papers describe methods of protecting a hypothetical transmission system which involves many of the problems that are of current interest.

Electronic Relay Applications. This project committee is continuing to watch developments in the field of electronic protective relays, and is continuing its study of the application of microwave channels to protective relaying.

Relaying of Interconnections Between Industrial and Utility Generating Systems. This committee has obtained information from 32 electrical utility systems with respect to their practice of relaying interconnections with their industrial customers. Replies showed no specific trend nor recommended practice. Protective devices are applied in accordance with the individual economic or operating situation. The committee is pursuing its analysis of the problem, and plans to complete its work in 1950, with a summary of basic considerations and of suggested solutions.

Relaying Performance of Current Transformers. The activity of this committee consisted of the following: In connection with the proposal to eliminate the 2.5-accuracy classification of current transformers for relaying services, a letter was sent to members of the Committee on Relays requesting comments; only two replies were received. Information published by the Westinghouse Electric Corporation on a new line of auxiliary current transformers was reported at a meeting of the Committee on Relays.

The following are reports of the four new project committees formed this year.

Pilot Wires. The objective of this committee is to bring up to date operating experience with pilot-wire circuits used for protective relaying and transferred tripping. It is the intent that operating experience for both leased and privately owned lines will be gathered for the years 1942–49, inclusive. It is also intended to compile information relative to new or unusual pilot-wire relay schemes.

Remote Tripping Schemes. It is the objective of this committee to collect all possible information on the engineering features of all types of existing remote tripping schemes and a statement of operating experience with each. It is hoped that an analysis of these data will enable the committee to ascertain what primary difficulties are being experienced with this type of relay protection and to determine the direction in which further research is required to eliminate fundamental difficulties. A questionnaire will be circulated shortly to request data from various operating companies which have such equipment installed. It is hoped that the data will be in such form that a conference session will be possible some time in the next 12 months.

Effect of Vibration and Shock on Relays. At the request of the Committee on Relays, the project committee was formed late in 1949 to study the effect of vibration and shock on relays. The first meeting was held during the Winter General Meeting, and another is scheduled to be held during the Great Lakes District Meeting. The committee plans to study the effect of vibration and shock on relays used on electric power systems and industrial applications. It is proposed to make a survey of the industry to determine what work has been done on vibration and shock in the past, and to use such information as may be available in this study. It is proposed to make laboratory tests on various types of switchboard panels and relay mountings to determine the range of both frequency and amplitude which is most critical. This will be supplemented by a number of field tests of vibration and shock in generating plants and substations. From this information, the committee proposes to prepare a paper offering a suggested guide, which should be useful to the industry in designing and applying protective relays to avoid difficulty from shock and vibration.

Project Committee on Relay Test Methods. This committee held one meeting, at which it was decided that the committee would attempt to collect data from all available sources on portable field testing equipment suitable for testing the majority of the more complicated types of relays. The data will then be reviewed by the project committee and one or two of the most efficient sets of equipment selected, possibly improved by suggestions, and this information will be presented to the Committee on Relays. Along with the description of any test equipment, there will be submitted general instructions on its applications and use. Some data have been furnished by committee members. However, since some very efficient equipment may not otherwise come to their knowledge, all members of the Committee on Relays will be asked to submit their ideas and recommendations.

Joint and Associated Projects. Through representation, the committee participates in the activities of the Instrument Transformer Subcommittee of the Committee on Transformers, with special attention to the relaying performance of current transformers and the transient performance of capacitance potential devices. Close co-ordination has been maintained with activities of the Committee on Carrier Current on items of joint interest.

COMMITTEE ON ROTATING MACHINERY

A report on the activities of each subcommittee is given in the following.

Single-Phase and Fractional-Horsepower Subcommittee. Review is in process of the test code for single-phase motors, and an attempt will be made to correlate with the Master Test Codes, AIEE *550* and *551*. Since small d-c motors are now officially within the scope of the committee, activity will be pushed along this line. A technical conference is planned for applications of fractional-horsepower motors, and may be held in Dayton in the spring of 1951.

D-C Subcommittee. Culminating more than two years of concentrated activity, including two committee papers on the subject, the subcommittee has now submitted a definite proposal for revision of Table I of ASA *C-50*, covering limiting observable temperature rise of d-c rotating machines. The proposal is based on data amassed from commercial testing and from a group of co-operative research tests, and features expansion of use of the resistance method as an alternate to a thermometer, as well as inclusion of Standards for short-time rated machines. The subcommittee is now active on the matter of d-c machine short-circuit currents.

Synchronous Machinery Subcommittee. An active technical paper program is bearing fruit. A review is being made of telephone influence factor and deviation factor.

Induction Machinery Subcommittee. A test code revision is being completed. An active program is being followed on technical papers.

Insulation Subcommittee. The subcommittee has concluded and the Standards Committee has accepted a revision of AIEE Standard *43* on insulation resistance testing. The subcommittee is being expanded to cover insulation practices as well as insulation resistance.

Test Code Co-ordinating Subcommittee. The subcommittee is working with other subcommittees and with ASA on revision and co-ordination of test codes, the dominant theme being proper use of the Master Test Codes *550* and *551* where possible to avoid duplication and mass of information.

Future Meetings. A symposium on induction, and possibly synchronous, machinery for oil well applications is being considered for the Fall General Meeting.

COMMITTEE ON SUBSTATIONS

The status of the projects on which work is in progress in the subcommittees and working groups of this committee is as follows.

Automatic and Supervisory Control Subcommittee. Besides collecting material for use in the next revision of American Standard *C37.2*—1945 for Automatic Station Control, Supervisory, and Telemetering Equipments, this subcommittee is studying rectifier reclosing control problems, standardization of annunicator systems, and the relative merits of insulating versus grounding d-c switching structures.

Distribution and Conversion Substations Subcommittee's study of the relative merits of bus voltage regulation versus feeder voltage regulation has resulted in the preparation of a paper by one of its members for the Middle Eastern District Meeting, in October, with a group of related papers to follow at a later meeting. Comparative studies of circuit breaker versus reclosing fuse application will shortly result in the preparation of a paper by another member of this subcommittee. Those working on the outdoor substation lighting problem have been in touch with the IES committee that is engaged in similar activities.

Transmission Substation Subcommittee met at the end of January to review progress made in the study of its assigned problems, including the basic structural design of substation structures for 110 kv and above, and safety considerations in substations.

Working Group on Basic 1-Line Diagrams was recently formed from personnel from both the Distribution and the Transmission Substation Subcommittees to review existing practices and classify current opinions regarding suitability of various fundamental connection schemes for substations. The work of this group will serve as the basis of further activity on the part of its two parent subcommittees.

Working Group on Device Function Numbers has been requested to recommend what minor changes in the present device function numbers should be made, after the returns from their nationally circulated questionnaire showed 78 per cent favored no changes.

Working Group on Rectifier Switchgear is devoting some attention to the formulation of equivalent constants for rectifiers, for use in calculating board studies, and to a study of the voltage surge problem.

Working Group on Substation Grounding Practice has prepared a 3-page questionnaire for widespread circulation, and has submitted this to all the main committee members for comments by mail.

Committee Meetings. In addition to subcommittee and working group meetings, meetings of the main committee were held on June 20, in Swampscott, on October 21, in Cincinnati, and on February 1, in New York. A meeting of the main committee is also tentatively scheduled for June 14, in Pasadena.

COMMITTEE ON SWITCHGEAR

AIEE Standard *20A*, which was published for trial use, is still on a trial basis. Further action on it is held up because of controversy over temperature rise clauses. It is hoped that data will be available shortly so that this point can be cleared up.

The proposed Standard *22A* was published in November 1949, and covers "Air Switches, Insulator Units, and Bus Supports, Combined With Air Interrupter Switches." It is now on a trial basis.

Subcommittee on Switches, Fuses and Insulators is actively working on a revision of Standard *25* for fuses above 600 volts.

Standard *27*, covering "Switchgear Assemblies," which had been recommended to the Standards Committee during the previous year. was returned last summer to the Committee on Switchgear, which, in turn, referred it back to the Subcommittee on Switchgear Assemblies. Objections from a number of sources to the temperature rise clauses have held up this Standard until the point can be clarified. During this waiting period, the subcommittee has been actively making minor revisions.

Proposed Standard *50* for "Automatic Circuit Reclosers for A-C Distribution Systems" was published in September of 1949 for a 1-year trial.

Circuit Breaker Subcommittee is actively working on the "Test Code for Power Circuit Breakers," and good progress has been made on the "Code for Low-Voltage Air Circuit Breakers." The "Guide for Application of Low-Voltage Air Circuit Breakers," which was prepared last year and presented at the Summer General Meeting, was published in *Electrical Engineering* and in pamphlet form during the summer. The subcommittee is also very active on the revision of the Standards for "A-C Power Circuit Breakers," "Methods for Determining the RMS Value of a Sinusoidal Current Wave and a Normal Frequency Recovery Voltage," and "Rated Control Voltages."

The Joint Subcommittee on Out-of-Phase High-Voltage Switching rendered its report, which was submitted by mail to the members of the Switchgear Committee. The Switchgear Committee, by letter-ballot, approved the report, recommended the discharge of the subcommittee, and recommended that the report be printed.

The committee sponsored a session at the Summer General Meeting, and also one at the Winter General Meeting.

COMMITTEE ON SYSTEM ENGINEERING

This committee was active at all three general meetings. The same subcommittee setups were continued into what is now the third year since this committee was formed. There was a realignment of personnel at the start of the year, with about one-fourth of the membership new members to stimulate the thinking in the committee and to give additional representation in several of the cities in the central west and southwest areas of the country.

It continues to be the policy of this committee to confine its program to one topic at each technical session and develop it fully as material is available. Because of the broad-gauged nature of the work, this has proved a more satisfactory approach than that normally followed in talking about detailed apparatus problems and their utilization which would fall to more specialized committees. A total of five normal papers and 13 conference papers were presented.

There were two committee meetings during the year, one each at the Fall and Winter General Meetings, and a full 1-day meeting in Chicago during May. The meetings held in connection with the general meetings were largely devoted to a review of the program to be followed at subsequent meetings. The meeting in Chicago covers a more adequate discussion of engineering aspects of the problems in addition to the review of the committee programs for future meetings. The success of this meeting will be weighed in determining whether it should be the annual policy of this committee.

System Planning Subcommittee. This subcommittee is sponsoring a group of five companion papers at the Summer and Pacific General Meeting, which will discuss design features and long-range planning of the systems in the Pacific Southwest. The extensive use of high-voltage transmission and the co-ordination of hydro and steam plants in that area will stimulate discussion of better planning practices. This subcommittee also sponsored several papers dealing with the use of the calculating board. This well-established tool for assistance in system planning is universally used, but new techniques for simplifying the application were described at the Fall General Meeting, with extensive interest as a companion to an earlier presentation the previous winter.

System Economics Subcommittee. This subcommittee considers both the economics of system operation and economics of over-all system engineering. In the first category, it has sponsored a paper which described the use of the calculating board as an operating tool in determining most economical loading of generating stations. The committee is now actively investigating problems associated with economics of interconnections, economics of high-cost high-efficiency generating capacity versus lower cost and lower efficiency capacity, rehabilitation of old plants, use of gas turbines for peak load, and economical sizes of units and power plants. Evaluation of system losses as a component of system capacity requirement is being studied also.

System Operations Subcommittee. This subcommittee sponsored a conference session at the Winter General Meeting, devoted to the subject "Operation of Systems at Leading Power Factor." The high power factor of systems now being experienced during light load periods due to installation of high-voltage underground and overhead transmission systems and extensive use of static capacitors has forced a review of the original concept of system operation requiring operation at substantial lagging power factor. Conference papers were presented by both generator manufacturers and power-system representatives, discussing the theory of operation at leading power factor and of a few cases of practical experience cited. The desirability of using automatic voltage regulators extensively in this operation was pointed out. A few companies had considered the necessity for loss of field relays in this connection to pre-

vent the sustained reactive demand and low voltage which results from loss of field. It was the opinion of the subcommittee that the conference did not develop any papers which could be presented on a formal basis, but the conclusion was reached by the speakers that leading power factor operation could be entered into on a moderate scale as the necessary safeguards are provided.

This subcommittee is studying the problem of adequate station electric auxiliaries in power stations during periods of system trouble. Several recent shutdowns of power systems have pointed out the need for studying this problem and reviewing operating procedures.

System Control Subcommittee. Although this subcommittee has not been active during the year, it is now studying two basic problems: the use of automatic load control on high-efficiency versus low-efficiency capacity; and the most desirable rate of load change on different types of generating equipment.

Joint Subcommittees. The subcommittee on out-of-phase high-voltage switching completed its study and presented a report which was accepted.

The Probability Subcommittee is active. It presented a second report at the Fall General Meeting, and now is extending its study to include more recent data on outages of turbine generator units operating at 700-pound or higher and hydro units.

The Committee on System Engineering was one of the sponsors of the Power Conference in Pittsburgh, Pa. It co-operated with the Committee on Industrial Power Systems in the program for April 20, and it presented two papers discussing problems associated with utility power-system supply to industrial plants.

COMMITTEE ON TRANSFORMERS

This committee consists of 33 members operating 15 working groups. In addition, 42, mostly members of the Institute, assist in the working group activities.

The following report gives changes in the status from that reported in last year's activities.

Co-ordinated Study of Life of Transformer Insulation Working Group. Apparatus and technique for this subject is all well developed, but some difficulty has arisen in obtaining satisfactory test samples. All of this work is limited to the pilot tests, which will form the basis for the final aging program.

Joint Subcommittee on Instrument Transformers. The subcommittee has a number of active subjects under discussion. "Application Guide for Grounding of Instrument Transformer Secondary Circuits and Cases" has been issued as ACO paper 50-65.

Subcommittee on Papers. This subcommittee has been responsible for obtaining, so far this year, 20 technical papers, and three conference papers. For the Summer and Pacific General Meeting, two sessions have been arranged.

Operating Guides for Regulators Working Group. Technical paper 49-228 has been referred to the Standards Committee for approval as a revision of ASA *C57.35*, dated 1948.

Short-Circuit Thermal Ratings of Induction and Step Regulators Working Group. The work on this assignment is progressing, but, at the present moment, is not ready for final decision. This subject deals primarily with the revision of ASA *C57.35*, and includes an explanation of paragraph 15.050 in connection with reclosing devices.

Magnetization Characteristics of Transformers Working Group. The scope of this assignment remains unchanged, and all the committee can report is progress.

Revision of Dielectric Tests Working Group. The same problems confront this working group as outlined in last year's report. Additional pressure is being exerted to bring up to date all impulse testing technique.

Guides for Operation and Maintenance of Dry-Type Transformers With Class-B Insulation Working Group. A report on the activities of this subcommittee has been submitted to both the Edison Electric Institute and the National Electrical Manufacturers Association for comment and review. The committee now awaits final comments of the National Electrical Manufacturers Association's Standards Committee before proceeding with any further changes to the Guides.

Co-ordination of Insulation Working Group. The work of this committee is progressing satisfactorily. Additional requests for information have been received.

Electronic Power Converters Working Group. This is a 1-man committee acting as liaison representative between the Committee on Electric Power Converters and the Committee on Transformers.

Methods of Making Temperature Tests on Transformers Working Group. Technical paper 50-99 has been issued as a preliminary report dealing with temperature tests. The committee is completing a report which will be a revision of ASA *C57.22.100*.

Power Factor Measurements Working Group. This originally was a 1-man committee, but has now been augmented with an additional member. The committee expects to complete this report by the end of the term.

Audible Noise in Transformers Working Group. A number of technical papers have appeared due to the activities of this group. Work has not been completed to a point where a report can be issued.

Hot-Spot Temperature Rise of Class-B Reactors Working Group. This is a new group and will cover Class-*B* reactors not now included in Table *C57.11.021*.

Permissible Maximum Oil Temperature in Service Working Group. This committee is working on the permissible maximum oil temperature of transformers in service. This subject is a study to determine whether it is permissible to operate sealed-type transformers in excess of the 100-degree-centigrade limitation in the present Guide *C57.32*.

COMMITTEE ON TRANSMISSION AND DISTRIBUTION

The general plan of operating the committee during the past year has been to continue the five subcommittees dealing with subjects within the scope of the main committee, and assign to them additional subjects of interest and importance in the transmission and distribution field as they arise, either from suggestions of committee members or others outside the committee. It has been the aim of the committee to clear all valuable and important information to Institute members by technical or conference papers, when any work has progressed to a point where it is of significant value. No attempt has been made to enhance the committee prestige by soliciting papers merely to get volume, but rather an effort has been made to obtain high-grade well-digested material for technical papers to record the progress of the art, promote constructive thinking, and study and investigate engineering features within the committee scope.

In the distribution field, a study is being made jointly with the Edison Electric Institute to obtain records of operating experience on distribution lines. This project, mentioned last year, is still in progress. The subject of distribution system economics is also being given attention.

In the lightning field, a laboratory study on the lightning strength of wood-pole lines in the subtransmission range is progressing. It is expected co-ordination of this work with field experience will be of value.

The predetermination of the lightning performance of transmission lines, which has been studied from a theoretical point of view, is reaching fruition in a committee report planned for the Summer and Pacific General Meeting. The Lightning Bibliography, which takes the place of the proposed second volume of the Lightning Reference Book, has been completed, and is expected to be published and made available for distribution in the summer of 1950. Two projects affecting transmission-line operation are progressing satisfactorily. One relates to a general survey of the causes of all transmission-line outages, and the other is a study of system recovery voltage.

After the co-ordinated technical session on capacitors at the Fall General Meeting, where an extensive discussion developed on capacitor operation, further study has been undertaken, mainly directed to capacitor temperature, tank corrosion, and short-time capacitor voltage ratings. A bibliography on this subject is in the course of preparation. Further public presentation on this subject is tentatively planned for 1951.

The series capacitor has been given some consideration, with regard to its application on high-voltage lines, as well as on low-voltage lines, to prevent voltage flicker.

In the conductor field, a study is being made on higher permissible conductor current loading, damage to conductors from vibration, and means of alleviating the trouble. A symposium on this latter subject is being planned for the Fall General Meeting.

A number of other subjects being dealt with in subcommittees have not yet reached the stage where present publicity would serve any useful purpose. During the year, the committee sponsored papers, solely or jointly with other committees, at general meetings, and at one District Meeting. It has offered papers within its field for the Middle Eastern District Meeting. For the Winter General Meeting, a session on technical features of high-voltage transmission is being arranged.

During the past year, technical papers passing through committee review have included those on power capacitors, recovery rates of voltage on distribution systems, arc extinction characteristics of gaps, insulator contamination and corrective measures, primary network systems, corona and radio-influence effects, distribution system planning, and operational characteristics.

For the 1950 Great Lakes District Meeting, three papers were offered, dealing with plan-

ning subtransmission and distribution systems, right-of-way brush control, and protection against conductor burndown.

For the Summer and Pacific General Meeting the committee is sponsoring papers on corona features, economics and lightning performance of high-voltage transmission lines, as well as other papers dealing with insulation co-ordination and interrupting ability of horn gaps.

COMMITTEE ON BASIC SCIENCES

The committee sponsored one session each at the Summer General Meeting, and the North Eastern District Meeting; a total of eight papers were presented at these meetings. It also sponsored a session on voltage induction during the Fall General Meeting, in the course of which five conference-type papers were presented. The committee had meetings at the Summer General Meeting and the Winter General Meeting, the prime object of which was the review of the activities and plans of the six subcommittees of the Committee on Basic Sciences, as well as discussion of items of general interest, such as the standardization of voltage and current notation and the nomenclature pertaining to sinusoidally varying alternating values.

Perhaps the most valuable service rendered to the members of the Institute by the committee is through the co-ordination and sponsorship of the work of its six subcommittees, all of which were very active during the past year; the symposia arranged by several of these subcommittees enjoyed a surprisingly large attendance, proving that the subject matter was of great interest to electrical engineers.

Reports on the activities of the subcommittees follow.

Subcommittee on Electrical Properties of Solids and Liquids. Because of the rapidly increasing use of semiconductor devices in electrical engineering, this subcommittee has been unusually active in the past year. A symposium on electrical properties of semiconductors and the transistor was held at the Summer General Meeting. Four articles covering the subject matter of the symposium appeared in *Electrical Engineering*, and have been assembled in a pamphlet. A second symposium of seven papers on "dielectrics" was held at the Winter General Meeting. These additional symposia were intended primarily for the nonspecialist engineer. For engineers who are specializing in semiconductor devices, a Conference on Electron Devices is to be held at the University of Michigan in June. This is jointly sponsored by the IRE and several AIEE committees.

Subcommittee on Energy Sources. The subcommittee sponsored its fourth Conference on Energy Sources at the Winter General Meeting. Three papers, dealing with recent developments in the field of electric batteries, were presented. The subcommittee is arranging for publication, in pamphlet form, of the first 14 papers presented since the formation of the subcommittee in 1946.

Subcommittee on Electric Circuit Theory. This subcommittee sponsored a conference on applications of conformal mapping in electric circuit analyses at the Fall General Meeting. Three papers were presented. Members of the subcommittee have been generous in devoting time to review the unusually large number of papers in electric circuit theory submitted to the Institute in recent months.

Subcommittee on Applied Mathematics. The subcommittee sponsored two conferences on applied mathematics, one at the Summer General Meeting and another at the Winter General Meeting. The subcommittee also expects to participate in the International Conference of Mathematicians, to be held in Boston, Mass., August 30 to September 6, 1950. The subcommittee has proposed to the Committee on Basic Sciences a new plan of activity, a full description of which was published in the May issue of *Electrical Engineering* under "Committee Activities." Briefly, the plan consists of inviting prominent mathematicians to become members of this subcommittee and enlisting their co-operation in solving engineering problems which would be submitted by the members of the Institute. Approximately ten prominent mathematicians have already signified their willingness to participate in this venture. The co-operation of the membership of the Institute in this project will determine to what extent the plan will be successful. The subcommittee is corresponding with the chairmen of various technical committees in the hope that it can stimulate interest in this project and obtain the problems in the fields of these committees, which lend themselves to mathematical treatment.

Subcommittee on Electrical Properties of Gases. This newly formed subcommittee held two meetings in 1949, one in April and one in November, both of which were attended by the full membership. Both of these meetings were concerned primarily with plans for a session on the electrical properties of gases at the 1950 Winter General Meeting. This session, the first organized and sponsored by this subcommittee, was held as scheduled; papers by four outstanding speakers were presented, and the attendance was very gratifying. The papers are scheduled for publication in *Electrical Engineering* as a series in succeeding issues. The members of the subcommittee held another meeting during the Winter General Meeting. Encouraged by the interest shown in the subject as shown by the large attendance, a similar session on the electrical properties of gases during the 1951 Winter General Meeting is planned.

Subcommittee on Magnetics. The subcommittee arranged for a symposium for the Winter General Meeting, consisting of seven papers on various subjects connected with magnetics, and a moving picture showing the movement of domain boundaries during magnetization. The attendance was exceedingly good, reaching 400 on Tuesday afternoon. This indicated a continuing interest in the subject, and another symposium is planned for the 1951 Winter General Meeting.

COMMITTEE ON COMPUTING DEVICES

The intense activity in the field of large-scale computing devices which arose following the end of the war is showing results in a steadily increasing number of papers in this field. There is intense competition among large laboratories in a development race which remains largely under cover. However, a tremendous range of applications is being investigated, and the possibility of using electronic computers in place of, or in addition to, present business machines seems attractive. There have been investigations of the possibility of using large-scale computers in place of a-c calculating boards and at the same time there have been improvements in the use of a-c calculating boards which have increased their efficiency appreciably.

In the field of large-scale computing itself, problems continue to grow in proportion as the ability to solve them grows, and there appears pressure for types of work which only a few years ago would not have been contemplated. The realization of the power of computing devices and the ease with which they can be manipulated has led to the growth of many special-purpose devices. As the principles become better known, it seems that the field of large-scale computers will be a well-defined engineering field, and a large part of the technical work will fall within electrical engineering.

Not much has been said with regard to continuous variable computers, but these are widely used and are being continuously improved. One reason for less information concerning them is that many applications are in the military field.

The Committee on Computing Devices held one session at the Winter General Meeting and at that time laid plans for the remainder of the year. These are resulting in two sessions at the Summer and Pacific General Meeting, one of which is on the application of large-scale computers in aircraft development, a possible session at the Fall General Meeting on applications of large computers to the petroleum industry, a session at the North Eastern District Meeting, a session at the coming Middle Eastern District Meeting, in October, and at least two sessions at the 1951 Winter General Meeting.

A special activity of the committee is the preparation of a bibliography covering the field of computers. This work is to be done in co-operation with a corresponding IRE committee, and it is hoped that a publication will result.

The committee has two subcommittees, one on continuous variable computers and one on digital computers. The work of these subcommittees has been devoted largely to the procurement of papers and the organization of those sessions which have been held or are contemplated.

There is an interesting side line in the field of the committee, in that many basic problems in the field are associated with others in the fields of communications, switching, control, and so forth. In this connection, not many persons realize that what is practically an entirely separate system of algebra has been built up especially for use in the computing device and associated fields. The committee is endeavoring to obtain an authoritative paper on this aspect of its work to see whether there is sufficient interest among electrical engineers to warrant presenting new developments of this type before the AIEE.

COMMITTEE ON ELECTRONIC POWER DEVICES

The activities of the committee during the year consisted mainly in completing projects previously initiated and encouraging papers on new developments and applications. Some new projects are also under consideration. Plans for the year were outlined at a meeting of the Administrative Subcommittee held September 12, 1949, in Pittsburgh, Pa. A meeting of the full committee was held on February 1, 1950, in New York. Meetings were held also by some of the subcommittees during the year.

The progress on the various projects is summarized in the following reports.

"*Survey on Operation of Mercury-Arc Rectifiers.*" The Subcommittee on Electronic Converter Applications has been making a survey on operation of mercury-arc rectifier installations. Questionnaires requesting operational data have been sent to rectifier users. A preliminary report on the results of the survey was presented at the Fall General Meeting. The final report will be presented at the Summer and Pacific General Meeting.

"*Report on Inductive Co-ordination on the D-C Side of Rectifier Installations.*" A working group of the Subcommittee on Applications is preparing a report on inductive co-ordination aspects relating to the d-c side of rectifier installations. A second draft of the report has been written and it is now expected to have the report completed in time for presentation at the Winter General Meeting.

"*Protection of Electronic Power Converters.*" A working group consisting of members of the Subcommittee on Electronic Power Converter Circuits and representatives of the Committee on Substations have been engaged in the preparation of a report on "Protection of Electronic Power Converters." This report is devoted primarily to the problem of protection of power rectifiers of the sizes and types usually encountered in railway, electrochemical, and general industrial applications. The report was presented in two parts at meetings in January and October 1949. These have been revised and combined into a single report for final presentation at the Summer and Pacific General Meeting and publication in the *Transactions*.

"*Bibliography on Electronic Power Converters.*" A bibliography covering the years from 1903 to the end of 1947 has been published by AIEE. The Subcommittee on Papers and Speakers reported no other activity.

"*Standards for Hot-Cathode Power Converters.*" The Subcommittee on Hot-Cathode Power Converters has been transferred from the Committee on Electronics to the Committee on Electronic Power Converters, in order to facilitate co-ordination with the pool cathode group. This subcommittee is engaged in the preparation of Standards for hot-cathode power converters. A set of definitions has been adopted by the subcommittee, and is being circulated in the main committee for comments.

The activities of the subcommittees and working groups, other than those reported on the foregoing projects, were carried on as follows.

Subcommittee on Electronic Power Converter Circuits is soliciting papers on surges, fault currents, protective gear, and rectifier power factor.

Subcommittee on Rectifier Transformers is soliciting papers on transformer noise and surge protection.

Subcommittee on Rectifying Devices is co-operating with other committees working on Standards for pool tubes, and is keeping the members of the main committee informed on such activities.

West Coast Subcommittee is co-ordinating AIEE activities relating to electronic power converters in that region.

Rectifier Standards. A working group has been organized to review the development of world standards on rectifiers, and to keep the members of the main committee informed on such activities.

Conference on Rectifier Cooling Systems. The committee is planning to hold a conference on cooling and corrosion problems relating to rectifier cooling systems during the fall in 1950.

COMMITTEE ON ELECTRONICS

The sponsorship of 2- or 3-day conferences relative to specific work areas in electronics has been one of the important continuing contributions of the committee for the past several years. Thus, the Second Annual Joint Conference on Electronic Instrumentation in Nucleonics and Medicine was held in New York, October 31, November 1–2, 1949. This was sponsored jointly by the Committees on Electronics, Nucleonics, and Instruments and Measurements within the AIEE, and the Nucleonics Studies Committee of the IRE. The conference was fully as successful as its predecessors, and plans have been formulated for a similar conference in the fall of 1950.

A 3-day Symposium on Improved Quality Electronic Components will be held in Washington early in May 1950, under the sponsorship of the AIEE Joint Subcommittee on Electronic Instruments, the Institute of Radio Engineers, and the Radio Manufacturers' Association. This is the third annual spring conference in a general series dealing with various aspects of engineering problems involved in the industrial applications of electronics.

The Subcommittee on Electron Tubes is sharing with the IRE Committee on Electron Tubes and Solid State Devices the sponsorship of the annual Conference on Electron Devices, to be held at the University of Michigan, Ann Arbor, Mich., June 22–23, 1950. This conference deals, on a completely informal basis, with new discoveries and projected methods and techniques in research and early development work on electron tubes and semiconductor devices.

Meetings of the committee were held in Swampscott in June 1949, at the National Electronics Conference in Chicago in September 1949, and at the Winter General Meeting.

The National Electronics Conference, held annually in the fall, in Chicago, is a very large middle-western forum for the presentation of papers of electronic interest, incorporating an extensive manufacturer's display of electronic instruments and new products; the *Proceedings* of the National Electronics Conference, published annually, contains in complete form the papers presented at the NEC.

It has become the policy of the Committee on Electronics to give substantial support to the NEC. Thus, during the past year, the chairman of the committee has served actively as the AIEE representative on the NEC Board of Directors, and various members of this and other AIEE committees have assisted in building greater strength into the industrial electronics part of the annual NEC program.

As a part of the continuing effort to bring to AIEE membership early reports on new electronic developments, various specific areas of work have been emphasized by holding three conference sessions at the Summer General Meeting and four at the Winter General Meeting.

A full program of papers of electronic interest is assured for the Summer and Pacific General Meeting, and for the Fall General Meeting.

The changes in the technical subcommittee structure during the year have been: the addition of Subcommittees on Electronic Systems Engineering and on Liaison With Electronic Heating, the transfer of the Subcommittee on Hot-Cathode Electronic Power Converters to the jurisdiction of the Committee on Electronic Power Converters, and the transfer of the Subcommittee on Electronic Aids to Medicine to the status of a joint subcommittee, sponsored also by the Instruments and Measurements Committee. At present, there are 19 subcommittees and two joint subcommittees.

With active advice and counsel from the chairman of the Subcommittee on Electronic Standards, there has been substantial progress towards Standards formulation in the following areas: X-Ray Tubes, Apparatus, and Applications; Electron Tubes, particularly High-Vacuum Tubes, Cathode-Ray Tubes, Gas-Filled Tubes, Phototubes, and Mercury-Pool Tubes.

COMMITTEE ON INSTRUMENTS AND MEASUREMENTS

The committee had a very interesting and active season. The personnel was changed so that 38 members were carried over from last year's roster, and 18 new members replaced 14 retiring members of last year's committee. Two vice-chairmen were named to assist in the operation of the committee, one for the East, and one for the West. The duties of the vice-chairman for the East were to procure and process papers originating in cities bordering on the Mississippi River and east of that river for technical sessions, and to arrange all technical programs sponsored by the committee at general or District meetings held in the afore-mentioned area. The duties of the vice-chairman for the West were similar except that he covered the area west of the Mississippi. The purpose of this arrangement was to ensure that instruments and measurements activities will be ably represented at all general and District meetings.

A committee meeting was held on September 19 to plan the year's program. A luncheon meeting was held January 31 to further the committee activities. This meeting was attended by 35 committee members and nine guests, including President Fairman, who spoke on joint activity of AIEE with other societies. A meeting is planned for May, in Philadelphia, and one will be held at the Summer and Pacific General Meeting.

The changes in the committee structure and the activities of the continuing subcommittees are reported as follows.

Changes

1. *Subcommittee for Revision of ASA's C-39* has been discontinued, since this work has been completed.

2. *Subcommittee on a Master Test Code for Resistance Measurements* has been discontinued, since the test code has been completed.

3. *Joint Subcommittee on Servomechanisms* has been promoted to full committee status.

4. *Subcommittee on Co-operation With the Instrument Society of America* has been named a standing subcommittee, since it is expected that the AIEE will continue to participate in the yearly instrument conference of the ISA.

Two interesting technical sessions were

arranged by this committee at the September 1949 conference held in St. Louis.

5. *Subcommittee on Electrical Aids to Medicine* has broadened its scope and is now a Joint Subcommittee of the Committees on Instruments and Measurements, Electronics, and Therapeutics.

6. *Subcommittee on Organization* was set up to study the relationship of the Committee on Instruments and Measurements to other technical committees and to make recommendations for future activities of the Committee on Instruments and Measurements.

7. *Joint AIEE–IRE Committee on High-Frequency Measurements* has been set up to handle jointly technical conferences, Standards, and definitions in this particular field. The AIEE representatives on this committee will form the Subcommittee on High-Frequency Measurements to act on matters pertinent to the AIEE.

8. *Subcommittee on Industrial Spectroscopy* has been formed, and will handle matters relating to design and characteristics of instruments and measurements pertinent to the field of industrial spectroscopy. It will promote technical sessions covering new or improved practices and determine Standards and definitions for this particular field. The final scope will be determined when the subcommittee becomes better organized and has its first meeting. One of its first activities was to schedule an informal conference session at the Winter General Meeting.

9. *Subcommittee on Master Test Code for Power Measurements* has been formed, and will draft a master code as required throughout the field of electrical engineering. It will be similar in construction to the Master Test Code for Resistance Measurements and the Master Test Code for Temperature Measurements which have been completed recently by the Committee on Instruments and Measurements.

Continuing Subcommittees

1. *Subcommittee on the Revision of Standard 4* (Measurement of Test Voltage in Dielectric Tests) is currently awaiting the prosecution of further tests and test data formulation from several commercial, industrial, and government laboratories. Completion of this work, particularly in the field of short-time impulse measurement, is awaited to assist the resulting work of standardization projected by this subcommittee.

2. *Subcommittee on Watt-hour Meters* issued a report entitled "Errors in Watt-hour Meter and Electrical Indicating Instrument Readings Caused by Harmonics in the Wave Form of the Supply Voltage," on January 24, 1950, for informal release to the New England Power Service Company and others technically interested. The subcommittee has tentatively established for itself the following fields of activity:

(*a*). Preparation of a bibliography on the subject of watt-hour meters and associated fields such as demand meters.

(*b*). The study of metering of loads of very short duration such as welders.

(*c*). A study of the performance of watt-hour meters on high frequencies, 400 cycles and above.

(*d*). A study of the testing of calibrating techniques for the watt-hour meter.

(*e*). The effect of temperature and the resulting errors when testing watt-hour meters out of doors at light loads.

Item *a* will be actively processed. Concurrently, the suitability of the other items will be appraised.

3. *Subcommittee on Definitions* still has under consideration the second draft of the definitions of Group 30, Instruments, Meters, and Meter Testing, which are being prepared by the *C42* Subcommittee, Number 6. Final approval of the second draft should be completed shortly.

4. *Subcommittee on Electrical Tests on Dielectric Measurements in the Field* is making a survey to determine current practices in field testing of dielectrics. A conference session on insulating oils was sponsored by this subcommittee during the Winter General Meeting.

5. *Subcommittee on a Master Test Code for Temperature Measurements* is revising Section 2 of the test code, AIEE *551*, in accordance with a request of the Standards Committee to make it identical with the corresponding section of AIEE Number *1*.

6. *Subcommittee on High-Frequency Measurements* sponsored a technical session at the Winter General Meeting.

7. *Subcommittee on Marking Varmeters and Related Instruments* has completed its survey with regard to practices in marking varmeters, and a report is in progress.

Joint Subcommittees

1. *Joint Subcommittee on Instrument Transformers* has been assisting actively in preparation of Standards and held a very successful technical session at the Winter General Meeting.

2. *Joint Subcommittee on Telemetering* has continued active collaboration with the National Telemetering Forum through attendance at NTF meetings and an increasing cross-membership. This subcommittee has accepted the responsibility of completing a "Glossary of Radio Telemetering Terms," which had been started by the Instrument Research Division of NACA. This joint subcommittee held a Technical Conference on Telemetering, jointly sponsored by the NTF in Philadelphia, May 24–26.

3. *Joint Subcommittee on Electronic Instruments* arranged a technical session on miscellaneous electronic instruments for the Winter General Meeting, and, with the assistance of the Joint Subcommittee on Telemetering, a technical session on radio telemetering for the 1949 Summer General Meeting. This joint subcommittee represented the AIEE in sponsoring jointly with IRE and the Radio Manufacturer's Association a Conference on Improved Quality Electronic Components, May 9–11, 1950, in Washington, D. C. Work has continued on the formulation of standardized forms for the specification of vacuum-tube voltmeters and for cathode-ray instruments, including a glossary of pertinent terminology.

4. *Joint Subcommittee on Nucleonic Instruments*, working with the Joint Subcommittee on Electrical Aids to Medicine and the IRE, sponsored the Second Annual Joint AIEE–IRE Conference on Electronic Instrumentation in Nucleonics and Medicine, held in New York, October 31, November 1–2, 1949. Plans already are under way for a 1950 conference. This subcommittee also sponsored a session on nucleonic instruments for the Winter General Meeting.

The Committee on Instruments and Measurements has been active in other fields through its representation on other committees of the AIEE, American Standards Association, and The American Society of Mechanical Engineers. In addition to the previously mentioned nine technical sessions, which were sponsored by its subcommittees, the committee also sponsored two sessions at the Summer General Meeting, one session at the Fall General Meeting, one session at the Winter General Meeting, and one session at the North Eastern District Meeting. This makes a total of 14 technical sessions for the 1949–50 season.

COMMITTEE ON METALLIC RECTIFIERS

During the past year, full meetings of this committee were held on June 24, in Swampscott, and on January 31, in New York.

The chief accomplishment of the year has been the preparation of Standards for Metallic Rectifiers, which include standard definitions and testing standards. The last revision of these Standards is in practically its final form.

At the January meeting, a new Subcommittee on Miniature Rectifiers was organized to take care of the special requirements of this type of equipment. At the same meeting, another subcommittee was set up for the purpose of developing necessary technical information which will be useful to users of metallic rectifiers and which will standardize many of the commonly used circuit ratings and other design or application factors.

Plans are being made for a conference session on metallic rectifiers at the Summer General Meeting in 1951.

COMMITTEE ON NUCLEONICS

The committee held two meetings during the year, one in connection with the Summer General Meeting, and the other during the Winter General Meeting.

The Subcommittee on Safety and Health Protection Against Radiation has been dissolved, and its functions transferred to the Joint Subcommittee on Nucleonic Instruments. A new Subcommittee on Nuclear Machines is in the process of being set up. Four subcommittees of this committee are now as follows: Joint Subcommittee on Nucleonic Instruments (Joint with the Committee on Instruments and Measurements), Subcommittee on Isotopic Tracers, Subcommittee on Nuclear Physics, and Subcommittee on Nuclear Machines.

The committee activities were directed toward bringing nucleonic information to the Institute membership. The committee sponsored or will sponsor conference sessions on nucleonics at the following meetings:

Summer General Meeting, four papers covering nucleonic instrumentation, sponsored by Subcommittee on Nucleonic Instruments.

Winter General Meeting, five papers covering nucleonic instrumentation, sponsored by Subcommittee on Nucleonic Instruments.

Joint AIEE/IRE Special Technical Conference on Electronic Instrumentation in Nucleonics and Medicine, New York, October 31, November 1 and 2, 1949, with 27 papers. A joint committee is preparing for a similar conference in October 1950.

The committee will be a joint sponsor of two sessions at the Summer and Pacific General Meeting, one with the Committee on Electronics and the other with the Committee on Electronic Power Converters.

A meeting of the Atomic Energy Commis-

sion Ad Hoc Committee on Technological Information for Industry was attended. This work is now being carried on by C. S. Rich, Editor, *Electrical Engineering*.

The committee has also co-operated in the review of the various nucleonics glossaries now nearing completion under the auspices of the National Research Council.

COMMITTEE ON THERAPEUTICS

Activity of this committee has consisted of review and approval for publication of a technical paper entitled "Electrical Instrumentation in Medical Research" by J. Malvern Benjamin, Jr., John Hale, Edwin L. Carstensen, and Howard E. Tompkins. Presentation of the paper is presently being scheduled.

Awards

COMMITTEE ON AWARD OF INSTITUTE PRIZES

The award of technical paper prizes was made on a Division basis for the first time during the current administrative year. The committee thinks the selection of the prize papers for the Divisions and also for the student prize paper contest can be handled most effectively by one committee, the Committee on Award of Institute Prizes, which should be composed of working groups in the several fields of interest, corresponding to the Divisions. This method of operation will assure that the prizes will continue to be Institute prizes and that the responsibility for selection will be definitely placed and recognized.

CHARLES LEGEYT FORTESCUE FELLOWSHIP COMMITTEE

The committee held one meeting, in New York, at which time business affairs were discussed and selection of recipients for the academic year 1950–51 was accomplished. Two fellowships, each carrying a stipend of $1,000, were granted. One recipient was Robert R. Johnson, of the University of Wisconsin, who will undertake graduate study in electrical engineering at Yale University. The other winner was Robert E. Horn, of Washington University in St. Louis, who will enter the graduate school of that university for study in electrical engineering. Both of these men had undergraduate records that approached perfection, and are well-balanced personalities as well.

The committee wishes to report a very encouraging response to the fellowship competition last winter. A record number of applications, 23, were received, and nearly all were from well-qualified young men. The committee believes that the fellowship continues to be a very worth-while project.

JOHN FRITZ MEDAL

The John Fritz Medal may be awarded annually for notable scientific or industrial achievements, by a board of award composed of representatives of the American Society of Civil Engineers, The American Society of Mechanical Engineers, American Institute of Mining and Metallurgical Engineers, and AIEE. The 1950 medal was awarded to Walter Hull Aldridge, President of the Texas Gulf Sulphur Company, with the following citation: "As Engineer of mines and statesman of industry who, by his rare technical and administrative skills, has importantly augmented the mineral production of our country and Canada, and who, by giving unselfishly of his wisdom and vision, has guided his professional colleagues to higher achievements."

The medal was presented to him on November 16, 1949, at a dinner at the University Club.

MARSTON MEDAL

The Marston Gold Medal is awarded to an alumnus of Iowa State College, of at least 30 years' standing, for achievement in engineering in a broad field. The board of award includes representatives of the college, and five engineering societies: ASCE, AIME, ASME, AIEE, and American Institute of Chemical Engineers.

WASHINGTON AWARD

The Washington Award for 1950 was made to Wilfred Sykes, President, Inland Steel Company, Chicago, Ill., and was presented at a dinner meeting on February 27. The award is made annually to an outstanding engineer, a citizen or resident of the United States, who ably has served human needs, and is administered by a commission representing the Western Society of Engineers, ASCE, AIME, ASME, and AIEE.

EDISON MEDAL

The Edison Medal for 1949 was awarded to Dr. K. B. McEachron, Manager of Engineering, Transformer and Allied Products Division, General Electric Company, Pittsfield, Mass., "for his contributions to the advancement of electrical science in the field of lightning and other high-voltage phenomena and for the application of this knowledge to the design and production of electric apparatus and systems," and was presented to him on February 1, 1950, in an evening session of the Winter General Meeting.

The medal may be awarded annually for meritorious achievement in electrical science, electrical engineering, or the electrical arts. Awards are made by a committee of 24 members of the Institute.

LAMME MEDAL

The Lamme Medal for 1949 was awarded to C. M. Laffoon, Manager of A-C Engineering Department, Westinghouse Electric Corporation, East Pittsburgh, Pa., "for outstanding contributions to the design of electrical machines, particularly large turbine generators and high-frequency generators." The medal will be presented to him on June 12, 1950, during the Summer and Pacific General Meeting.

The medal may be awarded annually by a committee of nine members to a member of the AIEE for "meritorious achievement in the development of electrical apparatus or machinery."

ALFRED NOBLE PRIZE

The Alfred Noble Prize award is made to a member of any grade of the ASCE, AIME, ASME, AIEE, or WSE for a technical paper of exceptional merit officially accepted for publication in any of their technical publications, provided the author has not passed his 31st birthday at the time the paper is submitted to the society in practically its final form. The prize award carries a handsome certificate and $350 cash. It is an important award, and greater publicity should be given to it by each of the participating societies in order that it will more fully stimulate the writing of papers by young members.

Ten AIEE papers were eligible, and from this group the paper "Relative Surface Voltage Gradients of Grouped Conductors" by M. Temoshok, Associate AIEE, was chosen as most worthy of the award.

After due consideration by the committee, the award was given to J. C. Fisher, ASME, for the paper "Anisotropic Plastic Flow."

It is interesting to note that Mr. Fisher is Research Associate, General Electric Research Laboratory, and that his paper is of the research type with related papers having been previously published in the *Journal of Applied Physics*. The AIEE paper "Relative Surface Voltage Gradients of Grouped Conductors" by Mr. Temoshok was of a different type, being a practical engineering type of paper of great value to the important development of long-distance power transmission at higher voltages than are in current use. It is very difficult when the committee is called upon to judge an engineering paper in comparison with a fundamental research paper.

The Alfred Noble Prize has been awarded each year since 1931, with the exception of 1934, 1935, and 1940, for a total of 16 times. It has been awarded to authors of AIEE papers eight times. However, there has been no award for an AIEE paper for the last five years.

HOOVER MEDAL

In September the Board of Award for the Hoover Medal awarded this distinguished honor to Dr. Frank B. Jewett, past-President of the AIEE. The Hoover Medal is awarded by a board representing the ASCE, AIME, ASME, and AIEE "for outstanding civic or humanitarian activities constituting distinguished public service." The citation accompanying this award is as follows:

FRANK B. JEWETT

> Great pioneer of industrial research, leader in molding scientific and engineering work to the needs of humanity, distinguished organizer of scientific effort for the service of the nation in war and peace.

The Institute suffered a great loss in the death of Dr. Jewett in November last. Accordingly, the medal was presented posthumously with appropriate ceremonies on Wednesday evening, February 1, during the Winter General Meeting of the Institute. Dr. Gano Dunn presented a statement of the achievements of the Medalist. The medal was presented by Dr. Scott Turner, Chairman of the Hoover Medal Board of Award, and it was received on behalf of his father by Harrison L. Jewett, Dr. Jewett's elder son, and himself a member of the Institute.

Joint Activities

UNITED ENGINEERING TRUSTEES, INC.

The funds and property held jointly by the four Founder Societies, including the Engineering Societies Building, the Engineering Societies Library, and the endowment funds of the Engineering Foundation, are administered by the United Engineering

Trustees, Inc., which also serves as treasurer of the Engineers' Council for Professional Development.

The building is fully occupied, and two of the Founder Societies have substantial amounts of space in other buildings.

The corporation is making studies of the possibility of securing a more modern building for the engineering societies.

ENGINEERING FOUNDATION

The Engineering Foundation is a department of the United Engineering Trustees, Inc., and its general objective is "the furtherance of research in science and engineering."

With the income from its endowment funds, it supports a broad range of research projects, now numbering about 15. Some of its most effective contributions are those supporting studies and analyses necessary in the early stages of organizing projects on such bases that financial support from other sources becomes available. A special study is being devoted to the future employment of foundation funds in advancing research.

ENGINEERING SOCIETIES LIBRARY

The library is a department of the United Engineering Trustees, Inc., and was formed by combining the separate libraries of the ACSE, AIME, ASME, and AIEE, and is conducted as a free public reference library.

In addition to affording the use of a large collection of engineering books and periodicals, the library renders special services such as bibliographies, translations, photostats, searches, and book loans by mail.

A broad survey has been made for the purpose of reorienting the library with other technical libraries in the United States and for improving its services.

Many valuable gifts of books and periodicals were received during the past year.

ENGINEERS' COUNCIL FOR PROFESSIONAL DEVELOPMENT

The principal activities of ECPD include programs for the guidance of young persons thinking of entering the engineering field, the accrediting of curricula of engineering schools, and encouragement and assistance to individuals in their engineering and cultural studies during several years following graduation. The council represents ASCE, AIME, ASME, AIEE, AIChE, the Engineering Institute of Canada, the American Society for Engineering Education, and the National Council of State Boards of Engineering Examiners.

ECPD approved and referred to the constituent societies the report of the Committee on Professional Recognition recommending the adoption of uniform grades of membership. The AIEE Board of Directors has approved the uniform grades for submission to the membership by letter ballot after they are approved by at least two other societies.

THE NATIONAL FIRE WASTE COUNCIL

A meeting of the National Fire Waste Council was held in Washington, D. C., Friday, March 31. The meeting was well attended, 55 of the 58 members having been present.

It was pointed out that the fire loss in 1949 amounted to 700 million dollars. This is equivalent to a $5 per capita loss. The association is attempting to reduce this loss which is enormous, particularly when it is compared with the figures for Britain, where the loss is 50 cents per capita, and with Germany, where it is 12 cents per capita. The majority of fires are due to carelessness; matches and smoking are responsible for the largest number. The next most common cause is defective wiring. The AIEE and its affiliates might well consider means of reducing this. The council is extremely anxious to reduce the fire loss, and it was pointed out by the speakers that the first step in any locality is the adoption of a fire prevention code; the second, the enforcement of this code. The National Board of Fire Underwriters has available a sample code. The council works through the Chambers of Commerce in the various localities and through these local Chambers attempts to educate the citizens and school children in fire protection. The council's plan is to organize in each Chamber a fire prevention committee to handle the problem in the locality.

In addition, the council is carrying on a hospital inspection program. This inspection is made available to hospitals, but no legal pressure is brought to bear. The committee reported that the larger hospitals welcome the inspection. They also stated that it was only the small hospitals that do not wish to be inspected. It was thought that the communities should be informed of the program; that they should assume the responsibility of seeing that it is carried out.

The Red Cross pointed out that there were 317 disasters (a disaster occurs when five or more families are involved) in 1949, of which 170 were caused by fires. It was stated that well over half of the disasters in this country are due to fires. The Red Cross is active in providing literature on fire prevention.

REPRESENTATIVES

A complete list of about 40 joint bodies upon which the Institute is represented appears in the Year Book and in the October issue of *Electrical Engineering* each year.

Appreciation

The Board of Directors notes with much satisfaction the continuing rapid increase in the membership and the substantial expansion in the activities of the general and technical committees, and the District, Section, and Branch officers and committees.

The Board of Directors expresses its deepest appreciation of the splendid co-operation received from all of these groups and from the membership in general.

Respectfully submitted for the Board of Directors.

H. H. HENLINE
Secretary

ACCOUNTANTS' CERTIFICATE

American Institute of Electrical Engineers:

We have examined the balance sheet of American Institute of Electrical Engineers, and schedule of securities owned, as of April 30, 1950, and the related statements of income and operating fund reserve and of restricted fund reserves for the year then ended. Our examination was made in accordance with generally accepted auditing standards, and accordingly included such tests of the accounting records and such other auditing procedures as we considered necessary in the circumstances.

In our opinion, the accompanying balance sheet, schedule of securities owned, and statements of income and operating fund reserve and of restricted fund reserves, respectively, present fairly the financial position of, and securities owned by, the Institute at April 30, 1950, and the results of its operations for the year then ended, in conformity with generally accepted accounting principles applied on a basis consistent with that of the preceding year.

(*Signed*) HASKINS & SELLS

New York,
May 17, 1950

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS

Balance Sheet, April 30, 1950

Exhibit A

ASSETS

Property Fund Assets:		
One-fourth interest in physical properties of United Engineering Trustees, Inc.:		
Land, buildings, and equipment (less depreciation and renewal reserve)	$320,525.41	
Funded depreciation and renewal reserve	177,923.07	
Total	$498,448.48	
Equipment:		
Library (volumes and fixtures)—estimated value	36,366.37	
Office furniture and fixtures (less reserve for depreciation, $33,849.74)	26,070.65	
Works of art, etc.	3,001.35	
Total property fund assets		$ 563,886.85
Restricted Fund Assets:		
Securities—at cost (quoted market value, $6 3,201.43)—Schedule 1	$572,455.35	
Cash (including $12,626.78 Canadian funds):		
Reserve capital fund	9,266.71	
Life Membership fund	2,409.81	
Member-for-Life fund	6,236.86	
International Electrical Congress of St. Louis Library fund	873.69	
Lamme Medal fund	160.00	
Mailloux fund	1,021.38	
Volta Memorial fund	401.48	
Retired employees insurance fund	2,000.00	
Accrued interest receivable	319.98	
Total restricted fund assets		595,145.26
Operating Fund Assets:		
Cash (not including $1,655.69 for Federal taxes withheld from employees)	$ 12,977.22	
Accounts receivable:		
Members—for dues (less reserve, $6,300.00)	12,849.68	
Advertisers	2,218.70	
Miscellaneous	4,388.71	
Technical Conference loans	650.00	
Accrued interest receivable	2,360.83	
Inventories:		
Transactions, etc.	1,764.00	
Text and cover paper	15,511.21	
Badges	12,336.24	
Deferred charges—Production charges for May issue of *Electrical Engineering*	16,089.81	
Total operating fund assets		81,146.40
Total		$1,240,178.51

LIABILITIES

Property Fund Reserve		$ 563,886.85
Restricted Fund Reserves (Exhibit *C*):		
Reserve capital fund	$543,295.65	
Life Membership fund	7,610.88	
Member-for-Life fund	11,288.94	
International Electrical Congress of St. Louis Library fund	6,382.33	
Lamme Medal fund	4,440.44	
Mailloux fund	1,021.38	
Volta Memorial fund	19,105.64	
Retired employees insurance fund	2,000.00	
Total restricted fund reserves		595,145.26
Operating Fund Reserves, Liabilities, etc.:		
Accounts payable	$ 40,122.69	
Deferred income:		
Dues received in advance	4,155.75	
Entrance fees and dues advanced by applicants for membership	1,815.75	
Subscriptions to publications received in advance	21,501.00	
Miscellaneous (including unallocated receipts)	1,493.48	
Operating fund reserve (Exhibit *B*)	12,057.73	
Total operating fund reserves, liabilities, etc.		81,146.40
Total		$1,240,178.51

Exhibit B

Statement of Income and Operating Fund Reserve for the Year Ended April 30, 1950

Income:		
Dues (including $187,998.00 allocated to *Electrical Engineering* subscriptions)	$410,958.61	
Advertising in *Electrical Engineering*	197,221.72	
Transactions subscriptions	11,208.56	
Electrical Engineering subscriptions	31,070.83	
Miscellaneous publications (preprints, Standards, and other publications)	53,097.10	
Students' fees	39,747.75	
Entrance fees	23,634.10	
Registration fees—Institute Meetings and Technical Conferences	19,365.62	
Membership badges	5,018.20	
Transfer fees	3,015.00	
Interest and dividends on investments of Reserve Capital Fund	24,700.69	
Total income		$819,038.18
Expenses:		
Publications expense:		
Electrical Engineering text $185,497.50		
Electrical Engineering advertising 102,816.89	$288,314.39	
Transactions	23,378.64	
Proceedings	32,834.51	
"Year Book"	17,771.06	
Miscellaneous publications (preprints, Standards, and other publications)	40,680.50	
Institute meetings	28,996.56	
Institute Sections	85,234.65	
Institute Branches, including paper prizes, etc.	8,366.65	
Finance Committee	1,088.88	
Headquarters Committee	946.14	
Membership Committee	22,364.67	
Standards Committee	17,229.69	
Technical Committees	16,195.48	
Committee on Public Relations	5,387.88	
Committee on Registration of Engineers	16.34	
Edison Medal Committee	277.02	
Forward	$589,083.06	$819,038.18

Income (forward)		$819,038.18
Expenses (forward)	$589,083.06	
Traveling expenses:		
Geographical Districts:		
Executive Committees	6,614.62	
Vice-Presidents	2,487.94	
Conferences on Student activities	9,901.28	
Board of Directors	10,114.00	
Nominating Committee	1,682.79	
President's appropriation	305.13	
Institute representatives	484.44	
Administrative expenses	105,836.71	
Geographical Districts—Branch paper prizes	280.63	
Institute prizes	626.25	
Retirement system AIEE—normal contribution	8,646.21	
American Standards Association	1,500.00	
Canadian Radio Technical Planning Board	10.00	
Canadian Council of Professional Engineers and Scientists	161.55	
Engineers' Council for Professional Development	2,008.50	
Engineering Foundation Project—Welding Research	250.00	
Engineers Joint Council	701.80	
Hoover Medal	234.26	
National Council of State Boards of Engineering Examiners	500.00	
United States National Committee—International Commission on Illumination (two years' appropriations)	600.00	
National Fire Protection Association (two years' dues)	200.00	
United Engineering Trustees, Inc.:		
Building assessments	19,547.72	
Library assessments	14,369.65	
Library retirement plan	3,123.20	
Lamme Medal Committee	155.51	
Membership badges	4,929.59	
Legal services	250.00	
Inventory adjustment—"Electrical Definitions"	537.00	
Rent, etc.—Editorial office, 500 Fifth Avenue	6,928.67	
Exchange allowances	5,581.32	
Provision for doubtful accounts	7,559.81	
Transfer to Retired Employees Insurance Fund (Exhibit *C*)	2,000.00	
Transfer to Property Fund Reserve for furniture and fixtures expenditures	12,587.16	
Total expenses		819,798.80
Excess of expenses over income for the year		$ 760.62
Operating fund reserve, May 1, 1949		22,818.35
Total		$ 22,057.73
Less—Repayment of advances from Reserve Capital Fund (net)		10,000.00
Operating fund reserve, April 30, 1950		$ 12,057.73

Exhibit C

Statement of Restricted Fund Reserves for the Year Ended April 30, 1950

	Total	Reserve Capital Fund	Member-for-Life Fund	Life Membership Fund	International Electrical Congress of St. Louis Library Fund	Lamme Medal Fund	Mailloux Fund	Volta Memorial Fund	Retired Employees Insurance Fund
Balance, May 1, 1949	$580,409.03	$531,660.79	$ 9,632.17	$8.312.51	$6,442.30	$4,440.44	$1,012.15	$18,908.67	
Additions:									
Income from bonds	$ 744.81		$ 125.00	$ 127.56	$ 135.28	$ 160.00		$ 196.97	
Interest on bank balances	73.80			53.57			$ 20.23		
Operating fund loan repayments:									
1948–1949	40,000.00	$ 40,000.00							
1949–1950	9,190.84	9,190.84							
Transfer from operating fund	4,043.55		2,043.55						$2,000.00
Supplementary fee	66.28			66.28					
Profit on sale of securities, etc.	1,634.86	1,634.86							
Total additions	$ 55,754.14	$ 50,825.70	$ 2,168.55	$ 247.41	$ 135.28	$ 160.00	$ 20.23	$ 196.97	$2,000.00
Total	$636,163.17	$582,486.49	$11,800.72	$8,559.92	$6,577.58	$4,600.44	$1,032.38	$19,105.64	$2,000.00
Deductions:									
Operating fund loan—1949–1950	$ 39,190.84	$ 39,190.84							
Authorized withdrawal from Life Membership fund	949.04			$ 949.04					
Purchase of medal, cost of engraving, etc. (exclusive of $99.30 paid from operating fund)	160.00					$ 160.00			
Library purchases	206.25				$ 195.25		$ 11.00		
Traveling expenses—District Branch prize winners	511.78		$ 511.78						
Total deductions	$ 41,017.91	$ 39,190.84	$ 511.78	$ 949.04	$ 195.25	$ 160.00	$ 11.00		
Balance, April 30, 1950 (Exhibit *A*)	$595,145.26	$543,295.65	$11,288.94	$7,610.88	$6,382.33	$4,440.44	$1,021.38	$19,105.64	$2,000.00

Securities Owned, April 30, 1950

Schedule 1

	Principal Amount of Bonds or Number of Shares of Stock	Restricted Funds: Reserve Capital Fund	Life Membership Fund	Member-for-Life Fund	International Electrical Congress of St. Louis Library Fund	Lamme Medal Fund	Volta Memorial Fund	Total
Railroad Bonds:								
Atlantic Coast Line first consolidated 4%, due 1952	$ 4,000.00					$4,253.78		$ 4,253.78
Baltimore & Ohio, Pittsburgh, Lake Erie & West Virginia System refunding 4%, due 1980	10,000.00	$ 6,450.00						6,450.00
New York Central Railroad Company 4% series *A* consolidated mortgage, due 1998	15,000.00	9,812.50						9,812.50
Northern Pacific Railway Company 4½% collateral trust, due 1975	15,000.00	15,307.50						15,307.50
Total railroad bonds		$ 31,570.00				$4,253.78		$ 35,823.78
Public Utility Bonds:								
American Telephone & Telegraph Company 2¾% convertible debentures, due 1961	$40,000.00	$ 33,154.75	$5,153.12		$5,457.85			$ 43,765.72
Consolidated Edison Company of New York, Incorporated 3% convertible debentures, due 1963	20,000.00	21,825.00						21,825.00
Total public utility bonds		$ 54,979.75	$5,153.12		$5,457.85			$ 65,590.72
United States Government Bonds:								
Treasury bonds, 2%, due March 15, 1952/50	$ 3,000.00	$ 3,074.22						$ 3,074.22
Treasury bonds 3%, due September 15, 1955/51	2,000.00						$ 2,081.66	2,081.66
Defense bonds series *G* 2½%, due December 1, 1954	18,000.00	13,000.00		$5,000.00				18,000.00
Treasury savings bonds series *G* 2½%, due September 1, 1955	40,000.00	40,000.00						40,000.00
Treasury savings bonds series *G* 2½%, due November 1, 1956	17,000.00	17,000.00						17,000.00
Treasury savings bonds series *G* 2½%, due May 1, 1957	20,000.00	20,000.00						20,000.00
Treasury savings bonds series *G* 2½%, due October 1, 1957	30,000.00	30,000.00						30,000.00
Treasury savings bonds series *G* 2½%, due May 1, 1961	30,000.00	30,000.00						30,000.00
Treasury savings bonds series *G* 2½%, due July 1, 1961	15,000.00	15,000.00						15,000.00
Treasury bonds 2¼%, due December 15, 1962/59	16,000.00						16,480.00	16,480.00
Total United States Government bonds		$168,074.22		$5,000.00			$18,561.66	$191,635.88
Total bonds		$254,623.97	$5,153.12	$5,000.00	$5,457.85	$4,253.78	$18,561.66	$293,050.38
Capital Stocks:								
American Can Company	60 shares	$ 4,988.40						$ 4,988.40
American Gas & Electric Company	400 shares	15,079.38						15,079.38
Atchison, Topeka & Santa Fe Railway Company preferred	200 shares	19,174.71						19,174.71
Boston Edison Company	200 shares	4,927.50						4,927.50
Commonwealth Edison Company	200 shares	7,580.68						7,580.68
Consolidated Natural Gas Company	100 shares	4,428.80						4,428.80
Dow Chemical Company $4 cumulative preferred, series *A*	100 shares	11,547.50						11,547.50
Eastman Kodak Company	300 shares	9,699.90						9,699.90
E. I. du Pont de Nemours & Company	300 shares	12,278.14						12,278.14
General Electric Company	200 shares	7,748.66						7,748.66
General Motors Corporation $5 preferred	200 shares	25,820.00						25,820.00
General Motors Corporation	100 shares	4,235.53						4,235.53
Gulf Oil Corporation	200 shares	12,264.20						12,264.20
Insurance Company of North America	120 shares	10,847.50						10,847.50
International Harvester Company	300 shares	5,030.50						5,030.50
Louisville & Nashville Railroad Company	100 shares	6,278.13						6,278.13
Ohio Edison Company 4.40% preferred	200 shares	21,279.25						21,279.25
Pacific Gas and Electric Company	200 shares	8,345.12						8,345.12
Public Service Electric and Gas Company $1.40 dividend preference common stock	300 shares	9,040.55						9,040.55
Scoville Manufacturing Company 3.65% cumulative preferred	100 shares	10,111.25						10,111.25
Sears, Roebuck and Co.	400 shares	6,014.97						6,014.97
Socony Vacuum Oil Company	400 shares	8,216.87						8,216.87
Standard Oil Company of Indiana	200 shares	8,170.32						8,170.32
Standard Oil Company of New Jersey	250 shares	12,049.69						12,049.69
Swedish Match Company class *B*	18 shares	100.00						100.00
Union Carbide & Carbon Corporation	300 shares	7,277.42						7,277.42
United Fruit Company	300 shares	11,985.00						11,985.00
United States Steel Corporation 7% cumulative preferred	100 shares	14,885.00						14,885.00
Total capital stocks		$279,404.97						$279,404.97
Total		$534,028.94	$5,153.12	$5,000.00	$5,457.85	$4,253.78	$18,561.66	$572,455.35

OF CURRENT INTEREST

EJC Considers Organization for Increased Unity of Engineering Profession

The group of representatives of large engineering societies, invited by Engineers Joint Council to explore the question of organization for increased unity of the engineering profession, had its second meeting on March 31, 1950.

This group consists of the following 16 engineering societies:

American Society of Civil Engineers
American Institute of Mining and Metallurgical Engineers
American Society of Mechanical Engineers
American Institute of Electrical Engineers
American Institute of Chemical Engineers
American Association of Engineers
American Society for Engineering Education
American Society of Heating and Ventilating Engineers
American Society of Refrigeration Engineers
American Water Works Association
Illuminating Engineering Society
Institute of Aeronautical Science
Institute of Radio Engineers
National Society of Professional Engineers
Society of Automotive Engineers
Society of Naval Architects and Marine Engineers

Fourteen of the 16 societies were represented at the recent meeting.

The major order of business was the consideration of the report of the Planning Committee of eight members, which were appointed at the previous meeting of the Exploratory Group on October 20, 1949. The Planning Committee had been charged with the duty of studying and reporting back a discussion of various approaches which had been suggested for the question of organizing for increased unity.

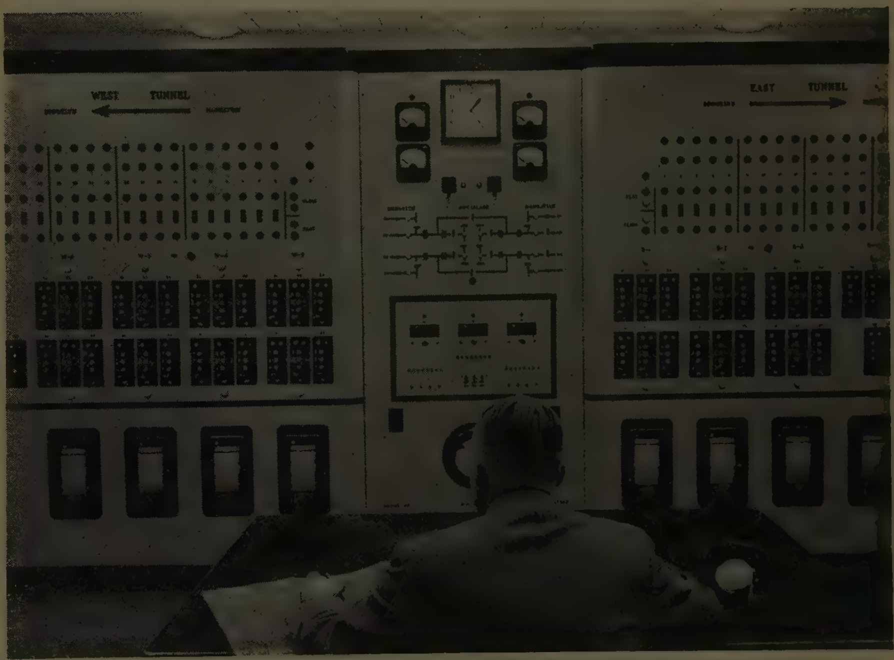
The Planning Committee had held five meetings at which the wide range of subjects involved in the question at hand had been discussed. The report of the committee submitted at this meeting included a discussion and comparative analysis of three possible approaches to the formation of a unity organization.

The report of the Planning Committee also included suggestions as to a number of basic principles which were recommended to serve as a guide in any formation of a "unity organization" of engineers. This term was used to designate the organization through which increased unity of the engineering profession might be brought about in the future without in any sense proposing that it be adopted as a name of such an organization.

The general aim of the unity organization will be to represent all engineers and engineering organizations who desire to be so represented in dealing with questions of interest to the profession as a whole. With this general aim in view, the following are proposed as basic principles to serve as a guide in determining the form of the unity organization and its relation to present engineering organizations:

1. The unity organization should include the affiliation of the major national engineering societies.
2. Affiliation should be open to all national engineering societies meeting certain general standards, on vote of the governing body. As illustrative of the type of standards which may be established, it may be required that to qualify as an affiliate an engineering society should have a grade of membership with qualifications at least as high as those prescribed by the unity organization as necessary for professional recognition. Also, as a practical matter, affiliation may be limited to societies having more than a specified minimum number of members who are qualified engineers, in accordance with this definition.
3. The unity organization should be formed by the modification and development of a present organization or organizations or by the integration of two or more present organizations rather than by establishment of an entirely new organization.
4. The government of the unity organization should reside in a governing body on which all qualified engineering groups who wish to be associated with the organization are appropriately represented.
5. The activities of the unity organization should be determined by the governing body under the terms of a broad statement of general purposes in the constitution of the organization. While a fairly complete statement of the general purposes of the organization should appear in its constitution, it does not appear useful to attempt to determine in advance what its specific activities would be at any given time. These would, no doubt, change from time to time in accordance with the wishes of the members.
6. Within its field of activity, the unity organization should be authorized to deal directly with government agencies and others as a representative of the engineering profession. For example, in such matters as the nomination of engineers to serve as members of committees and commissions, or the expression of opinions on public questions involving engineering, the unity organizations should be empowered to act directly without a referendum of its constituents.
7. To the extent practicable, the unity organization should take over present

Switchboard for Brooklyn–Battery Tunnel



The General Electric Company's main control switchboard for the new $80,000,000 Brooklyn–Battery Tunnel, second longest underwater tunnel in the world, is shown above. The new tunnel is 9,117 feet long and is second in length to the Mersey River Tunnel at Liverpool, England, which is 11,254 feet in length. More than 1,700 miles of wire link the components of the tunnel's complex electric system with each other and with this central "brain" located in the Service Building in Brooklyn. The operator is seated at his desk in the foreground, his normal post while watching the indicator lights on the board

co-operative activities of groups of nationa engineering societies, where such activities appropriately fall within the scope of the unity organization.

8. The unity organization should have its own offices and staff.

These principles were accepted by the Exploratory Group subject to such modifications as might be arrived at in further discussions. The report of the Planning Committee also presented a number of other questions requiring further consideration.

The discussion of the Exploratory Group centered about the three approaches to the form of organization included in the report of the Planning Committee. These three approaches would be as follows:

1. Expand and modify the present Engineers Joint Council so that the members of a larger number of engineering societies would be represented and so that representaion would be, to some extent, in proportion to membership of the different societies.

2. Expand and modify the present National Society of Professional Engineers with the understanding that the existing engineering societies co-operate by urging their members to join and by referring to that society items of a broad general nature which the society is in a position to handle.

3. Modify the National Society of Professional Engineers so that registration is not a requirement for individual membership, modify the Engineers Joint Council as in item 1, and combine the NSPE Board of Directors with the EJC to form a single governing body.

After a full discussion, the entire matter of preparing a further comparison of possible plans was referred to the Planning Committee for study. It is expected that the next report of the Planning Committee will be made to the Exploratory Group shortly after the summer vacation period.

Bell Laboratories Photograph the Pattern of Sound Waves

Actual photographs of the pattern of sound waves have been made recently by means of a new technique developed at Bell Telephone Laboratories, New York, N. Y. The method will be used for studying the sound waves from telephone receivers and similar communication equipment, and for observing microwave radio-wave patterns.

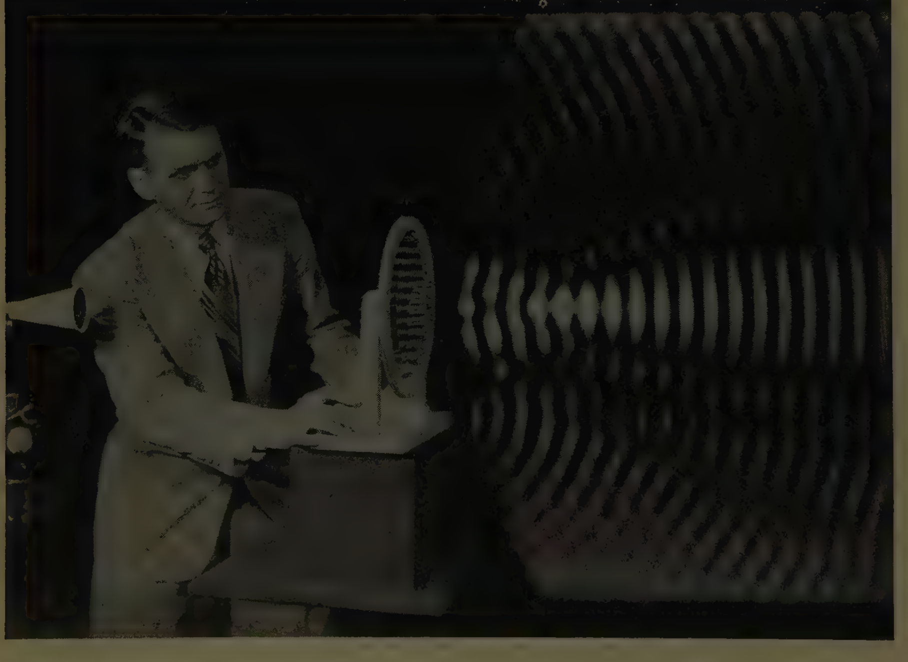
Equipment used in the work consists of a tiny microphone and a neon lamp, mounted on a swinging beam which scans the wave field. As the beam moves through the field, a clear picture of the sound radiation is built up by scanning, similar to the way television images are formed.

In one of the first experiments using the new technique, Bell Laboratories scientists made photographs showing the precise acoustic focusing effect of lenses. The lenses are similar to those used to focus the very short radio waves in microwave radio-relay systems. These systems are forming an increasingly important part of the nation's telephone and television transmission network.

The microphone used in taking the pictures of sound is about the size of a quarter. It is mounted on the end of an aluminum arm four feet long. Also on the end of the arm is a tiny, 110-volt neon lamp.

A small loud-speaker radiating a sound wave is directed at one side of the acoustic lens. On the other side of the lens, the metal arm swings up and down, inscribing a 3-foot arc through the path of the sound waves as they emerge from the focusing lens. Sound picked up by the microphone is carried to an audio amplifier. As the sound level varies, the brightness of the neon lamp varies in proportion.

Viewed in a darkened room, the lamp glows brightly, then fades, then brightens again. As it traces its vertical pattern, it automatically moves horizontally away from the lens. Thus, in a 10-minute time exposure, a sizable area of the focused sound-wave pattern may be photographed.



Pattern of sound waves photographed by scientists at Bell Telephone Laboratories. The wave pattern is produced by a scanning technique somewhat similar to that of television

80 Per Cent of Engineering Graduates Offered Jobs

Within three weeks of their commencement, four out of five engineers graduated this June in the largest class in the history of engineering education in America had accepted jobs or received job offers, members of the American Society for Engineering Education were told recently at a meeting at the University of Washington.

The report was based on a telegraphic survey of 117 engineering colleges throughout the country conducted by the manpower committee of the ASEE. The results showed that 62.5 per cent of all engineering graduates this year were placed by June 15 and an estimated 20 per cent more had received job offers but had made no commitments.

A similar survey in 1949 showed that 62 per cent of the graduating seniors were placed by July 1 of that year. Then placement continued throughout the summer months and by November nearly 95 per cent

Future Meetings of Other Societies

American Chemical Society. Chicago Section—Sixth National Chemical Exposition. September 5–9, 1950, Chicago Coliseum, Chicago, Ill.

American Society of Mechanical Engineers. 19th National Exposition of Power and Mechanical Engineering. November 27–December 2, 1950, Grand Central Palace, New York, N. Y.

American Standards Association. Annual Meeting. November 27–29, 1950, Waldorf-Astoria Hotel, New York, N. Y.

First United States International Trade Fair. August 7–20, 1950, Navy Pier, International Amphitheatre, Coliseum, and Arena, Chicago, Ill.

Illuminating Engineering Society. National Technical Conference. August 21–25, 1950, Hotel Huntington, Pasadena, Calif.

Institute of Traffic Engineers. Annual Meeting. September 24–27, 1950, Commodore Hotel, New York, N. Y.

Instrument Society of America. 1950 Instrument Conference and Exhibit. September 18–22, 1950, Memorial Auditorium, Buffalo, N. Y.

National Conference on Industrial Hydraulics. Sixth Annual Conference. October 18–19, 1950, Sherman Hotel, Chicago, Ill.

National Electrical Manufacturers Association. November 13–16, 1950, Chalfonte-Haddon Hall, Atlantic City, N. J.

National Research Council. 1950 Conference on Electrical Insulation. November 1–3, 1950, Pocono Manor Inn, Pocono Manor, Pa.

Society of Automotive Engineers. Transportation Meeting. October 16–18, 1950, Hotel Statler, New York, N. Y.

of the previous June graduates reported placement. Many others presumably failed to report jobs which they had accepted.

The outlook for the 35,000 engineers who will graduate in 1951 is considered favorable.

Motorola Begins Installation of 1,000-Mile Microwave System

Motorola, Inc., of Chicago, Ill., has started installation of a 1,000-mile microwave relay system for Mid-Valley Pipe Line Company which, when completed and placed in operation in September, will be the most extensive of its kind in the world. The multichannel system will furnish telephone, teletype, and extension of mobile radio communications from Longview, Tex., to Lima, Ohio.

Each relay station along the system will include a very-high-frequency remotely controlled transmitter and receiver unit for drop-off communications between any relay or terminal point of the microwave system and any Mid-Valley 2-way radio-equipped mobile unit. Messages will be carried along the microwave circuit to the relay station nearest the vehicle to which communications are directed, and then converted to the mobile frequency assigned to Mid-Valley. Company trucks and cars will use the 2-way radio systems just as though they were communicating directly with a very-high-frequency central station.

In addition to the circuit used for mobile communications, two circuits will be assigned to party-line dial-telephone systems, three to private-line dial-telephone systems, and another will carry a party-line teleprinter.

Telemetering of meter readings along the route to central points and supervisory control of valves and switches on the system from these same central points is planned for future expansion.

New Automatic Clutch Provides Infinite Gear Ratio Changes

An automatic variable-speed clutch pulley, which is automatically controlled by engine speed and which makes possible infinite gear-ratio changes on any kind of machinery on which a variable-speed belt can be used, has been developed by Charles H. Miner and the Driv-Waý Lite Company of Denver, Colo.

The new automatic clutch is centrifugally operated. In one of the two pulley halves, which operate along a central shaft connected to the engine, are several steel balls. When the speed of the engine is increased, centrifugal force of the steel balls pushes against the pulley half, forcing the pulley halves together, thereby carrying the belt up from the pulley shaft and automatically changing the engine from a low to a high speed ratio.

The belt revolves, on the other end, on a similar pulley which operates by spring action rather than by centrifugal force. The action of this pulley is determined by that of the main-drive pulley. When the pulley belt is resting high between the closed pulley halves of the drive pulley, it is low on the secondary pulley, and the engine is in high speed. When the opposite is true, the engine is in low speed.

The most important feature of the new automatic clutch is its simplicity. Varying performance, reduction or acceleration of starting and running speeds, may easily be obtained by inserting larger or smaller steel balls, aluminum rather than steel, or by changing the number of balls in two or four channels, depending upon the desired speed, acceleration, or "overdrive" required of the engine.

ASA Announces New Standards and Two Proposed Standards

Three new standard specifications for conduit and tubing used as raceways for electric wiring and cables have been announced by American Standards Association. They cover zinc-coated and enameled rigid-steel conduit, and zinc-coated electrical metallic tubing. Their purpose is to establish uniform dimensions and standard construction requirements for these products. The new American Standards include standard sizes in general use and detailed requirements for coatings, threading, identification, couplings, elbows, nipples, tests for ductility, thickness, quality of coating, and inspection procedure. Single copies of the three new American Standards are available from American Standards Association, 70 East 45th Street, New York, N. Y., at 50 cents each, and the titles are as follows:

Rigid Steel Conduit, Zinc Coated (*ASA C80.1*–1950); Rigid Steel Conduit, Enameled (*ASA C80.2*–1950); and Electrical Metallic Tubing, Zinc Coated (*ASA C80.3*–1950).

Two proposed American Standards on lamp ballasts have been published for a year's trial and criticism. The proposed Standards provide manufacturers with the performance characteristics of ballasts used for testing purposes in terms of, and in relation to, a reference current. Copies of the proposed American Standard Methods of Fluorescent Lamp Ballast, *C82.2*, are available from the American Standards Association at 50 cents per copy. The proposed American Standard Specification for Fluorescent Lamp Reference Ballasts is available at 35 cents per copy.

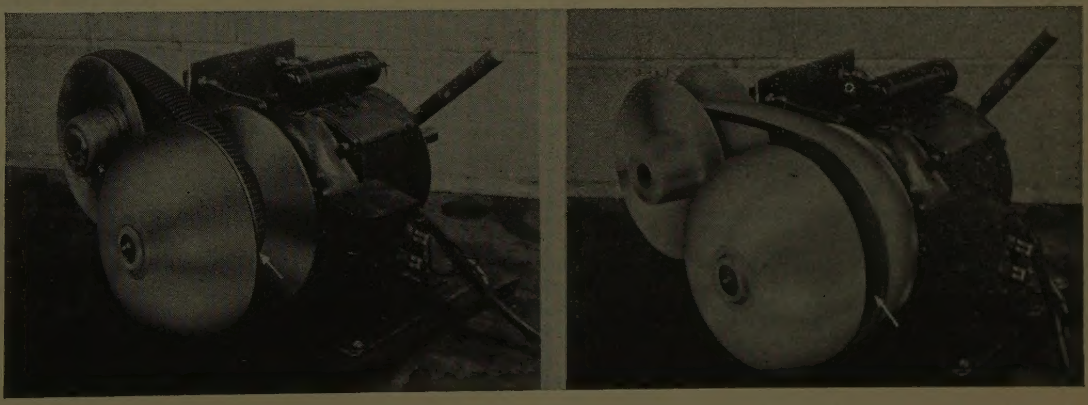
Two new and one revised Standard for laboratory standard-pressure microphones and for earphones have been announced by American Standards Association. The first covers the reciprocity technique for Pressure Calibration of Laboratory Standard Pressure Microphones (*Z24.4*–1949). The second (*Z24.8*–1949) gives specifications for these microphones. The third (*Z24.9*–1949) gives a method for Coupler Calibration of Earphones. Copies are available from American Standards Association as follows:

Z24.4–1949 (20 pages) 75 cents, *Z24.8*–1949 (12 pages) 50 cents, and *Z24.9*–1949 (20 pages) 75 cents.

Transmission Line Installed in Great Divide Tunnel

The difficult feat of installing a 69,000-volt electric power transmission line in the United States Bureau of Reclamation's $13^1/_2$-mile Alva B. Adams Irrigation Tunnel, which goes through the Great Divide, has been completed. The primary purpose of the tunnel is to carry irrigation water from the western slope of the Rocky Mountains in Colorado through the Continental Divide to the eastern slope. The cable line utilizes the tunnel as an economical route for electric power transfer between generating plants which are located on the two sides of the Great Divide.

The complexity of the cable installation resulted from the fact that it was necessary to bring all material and workmen into the $9^3/_4$-foot diameter tunnel from one end only since no other access points were available. The 69,000-volt cable is General Electric Company's high-pressure gas-filled type which utilizes a $5^9/_{16}$-inch diameter steel pipe as a container. The entire steel pipe is welded together to form effectively one continuous pipe which is hung from the tunnel ceiling where it will be just above the normal water level. In operation, the pipe is filled with nitrogen gas at 200 pounds pressure. This gas improves the electrical strength of the oil-impregnated paper insulation of the copper conductors and also



Left. Automatic clutch pulley in idling position. Belt resting low on drive pulley. Right. Pulley in running position. Belt resting high on drive pulley. Arrows in both figures indicate the pulley half which moves by centrifugal-force action

prevents air and water from entering the pipe in case of leaks.

The pipe was welded into half-mile sections outside of the tunnel and three cables pulled into each section. The pipe was then pulled up a wooden track into the tunnel, raised to the ceiling, and joined to the preceding lengths. The line is expected to be put into operation late this summer.

New NBS Laboratory Has 50,000,000-Volt Betatron

A 50,000,000-volt betatron, designed and constructed by the General Electric Company, has been installed in the National Bureau of Standards' new betatron laboratory. The new betatron extends the Bureau's high-energy research into the region from 2- to 50-million electron volts. For work at even higher energies, a 180-million-volt synchrotron, now being completed by General Electric, will be installed at the Bureau next year.

The NBS research program with these machines has four main aspects: the investigation of shielding and protection against high-energy radiations, the medical applications of these radiations, their industrial applications, and their basic physical properties.

X rays with energies between 10- and 70-million electron volts are now widely used in the medical treatment of deep-seated tumors. These high-energy radiations are directed to burn out a pinpoint of afflicted tissue deep within the human body without damaging the surrounding area. Proper protective precautions are of the greatest importance both to the patient and to the radiologist administering the treatment.

The National Bureau of Standards has already established standards for protection against low-energy X rays, and the new betatron research program will fill the need for standards of protection in the higher regions now available to medicine. The much deeper penetration of high-energy X rays requires entirely new scientific standards for full exploitation of these sources of radiation while maintaining adequate protection.

NY Better Business Bureau Aims for Improved TV Sales Practices

An action program to cut down drastically the overwhelming number of consumer complaints concerning radio, television, and home appliances was launched recently by the Better Business Bureau of New York City in co-operation with leading manufacturers, distributors, dealers, and service organizations in the metropolitan area.

The aim of the program is to establish and maintain standards for advertising and selling within the industry in order to reduce current faulty and misleading practices on the part of certain elements within the trade and to inform the public of basic facts they should know about purchase and service, thereby helping consumers to buy intelligently and to refrain from unjustified complaints.

In formulating this program, the Better Business Bureau of New York City secured the active co-operation and support of many responsible elements within the industry, who have responded by co-operating in a program providing for three main lines of action: voluntary adoption of standards to improve advertising, selling, and servicing of radios, television sets, and home appliances; establishment of a radio-television-appliance division in the Better Business Bureau to administer these standards, thereby assuring compliance by all elements within the industry, and to handle inquiries and complaints from the public and trade itself; and education of the public regarding the basic facts of radio and television sales and service.

To place the growing problem of consumer complaints and the action program for solving it before dealers and service companies, the Better Business Bureau called a meeting of 1,000 radio, television, and appliance dealers and television service companies on June 28, 1950, in the Engineering Societies Auditorium in New York City. At this meeting, standards for advertising and selling in the industry were agreed upon and the general program policy was accepted.

The Bureau has offered a booklet entitled, "Things You Should Know About the Purchase and Servicing of Television Receiver Sets," to all dealers, service companies, and distributors at cost for their free distribution to the public. Individual copies may be secured from the Better Business Bureau of New York City, 280 Broadway, New York 7, N. Y., at ten cents each.

Westinghouse to Employ Over 300 Engineers. The Westinghouse Electric Corporation will employ more than 300 engineering graduates this year, or approximately ten per cent more than were added last year. Approximately 50 per cent will be assigned to sales positions, 30 per cent to engineering departments, and 10 per cent to manufacturing departments. Several others will be added to the company's accounting and treasury departments.

Nonfogging Bathroom Mirror. A bathroom mirror which will not fog has been developed by the Charles Parker Company of Meriden, Conn. The mirror utilizes an electric heater made of electrically-conductive rubber which was designed by United States Rubber Company. The rubber heater is mounted behind the mirror and warms the glass to a temperature of 98 degrees Fahrenheit, which is enough to offset the condensation of moisture-laden steam. It operates on 110 volts and uses about the same amount of current as a 60-watt bulb. The heater is turned on and off with a switch mounted in one corner of the mirror. The heater consists of a layer of rubber which will conduct electricity, sandwiched between two layers of insulating rubber.

Atomic Golf Ball. An atomic golf ball that cannot "get lost" was demonstrated recently by the B. F. Goodrich Company of Akron, Ohio. Minute quantities of radioactive materials embedded under the cover of the ball make it possible for a caddy carrying a small portable Geiger counter to locate the "atomic" golf ball even when hidden in dense woods or deep rough. The location of a lost ball can be telegraphed by the Geiger counter in two ways: by a flashing light on the instrument, or by signals which the caddy can hear through headphones. The amount of radioactive material inside each ball is so small that there is no danger of radiation.

Large Summer Group at Oak Ridge. More than 100 faculty members and scientific personnel from universities and medical schools are spending the summer in Oak Ridge, Tenn., in the research laboratories of the United States Atomic Energy Commission. A large number of these individuals are from southern universities. While the bulk of the group is employed at Oak Ridge National Laboratory, others are working in the research laboratories of the electromagnetic and gaseous-diffusion uranium-separation plants and in the Medical Division of the Oak Ridge Institute of Nuclear Studies. They are mainly concerned with work on the peacetime applications of atomic energy.

Ozone Lamp Deodorizer. The fresh clean smell which prevails out of doors during an electric storm is being reproduced indoors on a small scale by means of a small lamp bulb introduced by the General Electric Company's Lamp Department. Ozone is produced at the flick of a switch by a new 4-watt lamp which is designed to dispel unwanted odors. The new lamp bulb is less than $1^1/_2$ inches in diameter and gives off just barely noticeable concentrations of ozone, which are useful in making the presence of odors less perceptible. The ozone produced by one lamp bulb is sufficient to mask odors in areas of up to 1,000 cubic feet.

Frank McKinless Joins Personnel Service. The Engineering Societies Personnel Service, Inc., has announced the appointment of Lieutenant Colonel Frank McKinless as manager of its Detroit, Mich., office. Colonel McKinless is a graduate of the Colorado School of Mines and has had over 25 years of experience in the design, production, sales, and management fields. He has served with the United States Marine Corps in both World War I and World War II and he was in charge of personnel procurement for the United States Marines in the New York District during World War II.

New Hot-Water Heating System. A new hot-water heating system for homes and other buildings has been successfully introduced in Detroit, Mich., by Copperheat Industries, Inc. The system employs a circulating pump attached to the gas or oil-fired boiler. When the thermostat is turned up, hot water is pushed through $^3/_4$-inch copper tubing at a 10-foot per second rate. New-type radiators in each room have individual small blowers with both thermostatic and manual control. Heat is pushed out rapidly across the floors. This system, known as "Copperheating," is claimed to give heat faster from a cold start than any other system and to deliver hot-water heat for only slightly more than the cost of warm air.

LETTERS TO THE EDITOR

INSTITUTE members and subscribers are invited to contribute to these columns expressions of opinion dealing with published articles, technical papers, or other subjects of general professional interest. While endeavoring to publish as many letters as possible, Electrical Engineering reserves the right to publish them in whole or in part or to reject them entirely. Statements in letters are expressly understood to be made by the writers. Publication here in no wise constitutes endorsement or recognition by the AIEE. All letters submitted for publication should be typewritten, double-spaced, not carbon copies. Any illustrations should be submitted in duplicate, one copy an inked drawing without lettering, the other lettered. Captions should be supplied for all illustrations.

Nonlinear Functions

To the Editor:

In a recent letter to the editor from Howard Hamer (*EE, May '50, pp 480–1*), it was remarked that abrupt mechanical nonlinearities frequently cannot be represented by simple diode limiters as implied in the article "Nonlinear Functions in an Analogue Computer" by the writer, C. H. Wilts, with G. D. McCann and B. N. Locanthi (*EE, Jan '50, p 26*). We did not wish to imply that all conceivable abrupt nonlinearities in mechanical systems could be represented by a single simple limiter. However, we did not want to hinder understanding of the principles by using an example with a complex analogue. For this reason we chose a velocity and position limited servo motor in which the inertia, or, more properly, the time delay produced by the inertia, was negligible. For this case the analogue of Figure 16 of the original paper (AIEE *Transactions*, volume 68, 1949) is correct.

If the delay is appreciable the circuit is more complex, but not to the extent of the differential analyzer analogue given by Mr. Hamer. This serves, we feel, to point out a fundamental difference between the two types of computers. The electric analogue computer normally uses analogues in which proper treatment of, for example, a position limitation automatically gives proper values to velocity and acceleration.

In an actual physical system, a mechanical stop is equivalent to a sudden enormous discontinuity in the spring constant. If inertia effects are important, then the analogue of the afore-mentioned Figure 16 cannot be used, but an inductor and resistor in series with a nonlinear capacitor, as shown in the lower circuit of Figure 1 of the article (Figure 8*C* of the original paper), provides a correct analogue. The amplifier gain A_2 must be large enough to make the stop sufficiently "stiff," and the second voltage limiter is, of course, omitted.

C. H. WILTS (A '48)
(California Institute of Technology, Pasadena, Calif.)

NEW BOOKS • • • • •

The following new books are among those recently received at the Engineering Societies Library. Unless otherwise specified, books listed have been presented by the publishers. The Institute assumes no responsibility for statements made in the following summaries, information for which is taken from the prefaces of the books in question.

Library Services

ENGINEERING Societies Library books may be borrowed by mail by AIEE members for a small handling charge. The library also prepares bibliographies, maintains search and photostat services, and can provide microfilm copies of any item in its collection. Address inquiries to Ralph H. Phelps, Director, Engineering Societies Library, 29 West 39th St., New York 18, N. Y.

ADVANCES IN ELECTRONICS. Edited by L. Martin. Volume II. Academic Press, Publishers, New York, N. Y., 1950. 378 pages, illustrations, diagrams, charts, tables, 9¼ by 6 inches, cloth, $7.60. The second in an annual series; in contrast to the first volume, articles from European contributors are included, and the contents show a predominance of physical electronics. Electron lenses; the manufacture and design of cathode-ray tubes; numerical methods in electron optics; cathodoluminescence; dielectric breakdown; microwave magnetron; ferromagnetic phenomena at microwave frequencies; and microwave spectrology are the specific topics covered.

DESIGN OF DIRECT CURRENT MACHINES. By L. Greenwood. Macdonald and Company, (Publishers) Ltd., Ludgate Hill, London, E.C.4, England, 1949. 222 pages, illustrations, diagrams, charts, tables, 8¾ by 5½ inches, cloth, 25s. Written for senior students and junior designers, the book embodies the procedure and methods used in the professional designing of electric machines. Metric units are used. A completely calculated design is given both in the text and on a typical commercial design sheet. A chapter on mechanical construction is included, and an appendix covers the design of centrifugal fans.

ÉCHELLES DE CONVERSION DES UNITÉS ANGLO-SAXONNES EN UNITÉS METRIQUÉS. By J. Bernot. Dunod, Paris, France, 1950. No pagination, charts, tables, 11¾ by 7½ inches, paper, 490 frs. Logarithmic comparison scales are given for the conversion of units from the metric to the English and American systems and conversely. Units of length, area, volume, capacity, mass, force, pressure, velocity, acceleration, energy, temperature, heat, and miles per gallon are the items dealt with in this way. Skeleton tables of conversion factors for these and related units accompany the scales. Numbered half-scales are provided for the computer's own adaptations.

EFFECTIVE TEACHING, A MANUAL FOR ENGINEERING INSTRUCTORS. By F. C. Morris, prepared under the sponsorship of American Society for Engineering Education. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England; 1950. 86 pages, illustrations, diagrams, tables, 9 by 6 inches, paper, $0.60. A guide for engineering instructors who are interested in the improvement of their teaching methods. It is designed to give first principles of good teaching and to point out some of the more common teaching faults. Definite directions are given for the effective handling of basic activities.

ELECTRIC CABLES. By F. W. Main. Third edition. Sir Isaac Pitman and Sons, London, England, 1949. 142 pages, illustrations, diagrams, charts, tables, 7½ by 5 inches, linen, 12s.6d. Serves as a guide to the properties, construction, installation, and maintenance of electric cables. It covers the wide range of cables used for lighting, power, telegraphy, and telephony, their technical characteristics and methods of manufacture. In addition, chapters are devoted to supertension cables and to testing procedures.

FUNDAMENTALS OF RADIO-VALVE TECHNIQUE. By J. Deketh. N. V. Philips' Gloeilampenfabrieken, Eindhoven (Netherlands), 1949. 535 pages, illustrations, diagrams, charts, tables, 9¼ by 6¼ inches, cloth, 35s. This book, the first of a series dealing with characteristics and circuits of vacuum tubes, serves as an introduction to the physical fundamentals, properties, designs, and applications of radio-receiver and power-amplifier tubes. The construction and manufacture of vacuum tubes are briefly treated. Conventional electrostatic and electromagnetic units as well as the rationalized Giorgi system of units are used. Mathematical treatment is restricted to essentials. The appendix contains definitions, formulae, and tables giving every kind of datum likely to be useful to those who are designing vacuum tubes.

INDEX OF NOMOGRAMS. Compiled and edited by D. P. Adams. Published by John Wiley and Sons, New York, N. Y.; Technology Press of Massachusetts Institute of Technology; and Chapman & Hall, Ltd., London, England; 1950. 174 pages, 9¼ by 7¼ inches, cloth, $4. This index lists more than 1,700 published nomograms in 97 important periodicals and thus serves as an invaluable time-saver in the repeated solution of mathematical formulas. It is divided into two main parts. Index *A* contains an alphabetical list of key words which are associated with each of the diagrams and a key number permitting reference to Index *B* where the periodical, date of issue, volume, number, and page of the nomogram are listed. Abbreviations of the variables employed in each diagram are listed at the beginning of Index *B*.

DIE MAXWELLSCHE THEORIE IN VERÄNDERTER FORMULIERUNG. By L. Kneissler. Springer-Verlag, Vienna, Austria, 1949. 51 pages, tables, 8¾ by 5¾ inches, paper, $1.50. The purpose of this booklet is to provide a variation to the Maxwell theory to solve the difficulties arising when the theory is applied to dielectric materials, magnetizable materials, and to electromagnetic fields.

(The) METRE-KILOGRAM-SECOND SYSTEM OF ELECTRICAL UNITS. By R. K. Sas and F. B. Pidduck. John Wiley and Sons, New York, N. Y. Methuen and Company, Ltd., London, England; 1947. 60 pages, diagrams, tables, 7 by 4¼ inches, cloth, $1. The unitary meter-kilogram-second system, adopted in 1938 by the International Electrotechnical Commission, is described in detail, with brief discussion of its relation to other systems and reasons for its adoption. A list of important formulas is given at the end of the book.

MICROWAVE ELECTRONICS. By J. C. Slater. D. Van Nostrand Company, Toronto, Ontario, Canada; New York, N. Y.; London, England; 1950. 406 pages, diagrams, charts, tables, 9¼ by 6 inches, cloth, $6. A unified account of the principles of wartime and postwar research in microwave electronics conducted at the Bell Telephone Laboratories and at the Radiation Laboratory of the Massachusetts Institute of Technology. Fundamental in approach, it covers the field in a detailed manner and applies the fundamental theory to the klystron, the linear accelerator, the cyclotron, the synchrotron, the traveling wave amplifier, and the magnetron.

NONLINEAR VIBRATIONS IN MECHANICAL AND ELECTRICAL SYSTEMS. (Pure and Applied Mathematics, Volume II). By J. J. Stoker. Interscience Publishers, New York, N. Y., and London, England, 1950. 273 pages, diagrams, charts, tables, 9¼ by 6 inches, linen, $5. A connected and systematic account of the theory and techniques of nonlinear vibrations occurring in systems with one degree of freedom. The author emphasizes the various known types of physical problems in the field. For the most of the book a knowledge of ordinary differential equations is sufficient, but more rigorous mathematical treatments are developed in the accompanying appendixes.

(The) ORGANIZATION OF INDUSTRIAL SCIENTIFIC RESEARCH. By C. E. K. Mees and J. A. Leermakers. Second edition. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England; 1950. 383 pages, diagrams, charts, tables, 9¼ by 6 inches, linen, $5. Presents an account of the history and development of industrial scientific research, the general principles of its conduct, and the methods actually used for the organization of industrial research laboratories. Detailed information is provided on the selection of a program, the direction of research, the financial administration of

the laboratory, and a number of auxiliary services. Data are included on the design of a laboratory for a specific industry. Particular examples are cited of government and large industry procedures.

PATENT PRACTICE AND MANAGEMENT FOR INVENTORS AND EXECUTIVES. By R. Calvert, with foreword by A. N. Mann. Scarsdale Press, Box 536, Scarsdale, N. Y., 1950. 371 pages, illustrations, $9^1/_2$ by 6 inches, cloth, $5. Beginning with a discussion of "what to patent," this book goes on to present not only the essentials of patent law, but also a wide range of associated problems which may have to be dealt with under various conditions. The emphasis is on procedures for obtaining patents, using them, and administering the patent policy to stimulate research, invention, and morale.

PERMANENT MAGNETS. By F. G. Spreadbury. Sir Isaac Pitman and Sons, Ltd., London, England, 1949. 280 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, 35s. This comprehensive treatment of the subject describes permanent magnet materials, magnet design, and the applications of permanent magnets. Magnetic leakage and magnetic measurements are dealt with, and introductory chapters cover the essentials of electromagnetism and magnetic theory. The last two chapters discuss magnetization and demagnetization. The mathematical analyses are supplemented by numerous graphs.

PIEZOELECTRIC CRYSTALS AND THEIR APPLICATION TO ULTRASONICS. By W. P. Mason D. Van Nostrand Company, Toronto, Ontario, Canada;. New York, N. Y.; and London England; 1950. 508 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by $6^1/_4$ inches, cloth, $7.50. This book covers in detail both the experimental and theoretical aspects of the crystal research program developed over the past decade at the Bell Telephone Laboratory. Chapters on crystallographic systems, stresses and strains, thermal and electric relations are included, as well as an appendix showing how tensors can be applied to calculating the properties of rotated systems. Emphasis is placed on the discovery and development of synthetic crystals to replace quartz, and on practical methods for the cutting, mounting, and so forth, of crystals. The production and measurement of ultrasonic waves in gases, liquids, and solids are described in the last three chapters.

POWER SYSTEM INTERCONNECTION (TRANSMISSION PROBLEMS). By H. Rissik. Second edition. Sir Isaac Pitman and Sons, Ltd., London, England, 1950. 239 pages, diagrams, charts, tables, $8^3/_4$ by $5^3/_4$ inches, cloth, 25s. The purpose of this book is to acquaint the practicing engineer, as well as the advanced student, with the several analytical and semigraphical methods for calculating the performance of interconnected power systems. Theoretical matter is also included to enable the reader to understand and formulate solutions for the special problems involved. There are many diagrams, and a chronological bibliography of the most important references in the English language with some foreign references is included.

(The) PRINCIPLES OF TELEVISION RECEPTION. By A. W. Keen. Sir Isaac Pitman and Sons, Ltd., London, England, 1949. 319 pages, illustrations, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, linen, 30s. Written for the technician and service engineer, this book provides a nonmathematical introduction to receiver theory. The material covered falls into four main groups: a general outline of the complete television process; stage-by-stage examination of the complete receiver; description of receiver accessories; review of the problem of television transmission in natural color. Both British and American practices are covered.

RECENT ADVANCES IN RADIO RECEIVERS. By L. A. Moxon. Cambridge University Press, American Branch, 51 Madison Avenue, New York, N. Y. University Press, Cambridge and London, England, 1949, 183 pages, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $3.75 (18s., England). Intended particularly to bring the designer up to date on the war-years' advances in the field, this book discusses fully the factors contributing to "noise" in amplifiers. Modern methods of design for the improvement of signal-to-noise ratio are fully explained. The main emphasis is on receivers for radar, and on the design of intermediate-frequency amplifiers to follow the crystal frequency changer. In common with all volumes of this series, the theoretical treatment is essentially physical.

REFLECTIONS OF A PHYSICIST. By P. W. Bridgman. Philosophical Library, 15 East 40th Street, New York 16, N. Y., 1950. 392 pages, $8^3/_4$ by $5^1/_2$ inches, cloth, $5. Contains most of the nontechnical articles written by the author, together with three papers published for the first time. The articles are arranged in five groups. The first deals with some of the characteristics of the operational method; the second, with applications of the method to scientific situations; the third, with the social environment of the scientist; the fourth, with situations due to political change; and the fifth examines some of the possibilities in stoie for the human race.

RURAL ELECTRIFICATION ENGINEERING. By U. F. Earp. McGraw-Hill Book Company, New York, N. Y.; Toronto, Ontario, Canada; London, England; 1950. 313 pages, illustrations, diagrams, charts, maps, tables, $9^1/_4$ by 6 inches, linen, $3.50. Designed as a text for professional agricultural engineering courses in rural electrification, it covers the fundamental design features of rural distribution lines, the basic factors underlying the application of electricity to heat, light and power, and the broad administrative considerations underlying a sound and progressive rural electrification program. Basic fundamentals are emphasized, and application data subject to obsolescence are minimized.

TABLES OF THE BESSEL FUNCTIONS OF THE FIRST KIND OF ORDERS 64 THROUGH 78. (Annals of the Computation Laboratory of Harvard University, volume 13). By the Staff of the Computation Laboratory, Harvard University Press, Cambridge, Mass., 1949. 566 pages, tables, $10^3/_4$ by 8 inches, cloth, $8. Continuing the Bessel functions tabulation which constitutes the bulk of this series of computation tables, the present volume provides, as usual, 10-place figures for the range specified. The methods employed in the computation and the means of interpolation within them are explained in the introductions to volumes 3 and 4 of the series.

TABLES OF THE FUNCTION $\frac{\sin \phi}{\phi}$ AND OF ITS FIRST 11 DERIVATIVES. (Annals of the Computation Laboratory of Harvard University, volume 22). By the Staff of the Computation Laboratory, Harvard University Press, Cambridge, Mass., 1949, 241 pages, diagrams, tables, $10^3/_4$ by 8 in., cloth, $8. Fundamental in the analysis of a large variety of problems connected with the Fourier transforms of distribution functions, these tables find application in the fields of sound, statistics, optics, and antenna theory. Nine-place tables are given of the function, on a half-degree mesh, and with a range of ten revolutions. The full scope of the tabulation is extended to its first 11 derivatives.

TABLES OF THE GENERALIZED EXPONENTIAL-INTEGRAL FUNCTIONS. (Annals of the Computation Laboratory of Harvard University, volume 21). By the Staff of the Computation Laboratory, Harvard University Press, Cambridge, Mass., 1949. 416 pages, tables, $10^3/_4$ by 8 inches, cloth, $8. Used in antenna theory, like the previously tabulated generalized sine- and cosine-integral functions, these functions provide solutions of the general wave equation in the case of a dissipative medium. They are tabulated to six decimal places, together with their differences in both directions. Computation and interpolation methods are explained in the introduction.

AERIALS FOR CENTIMETRE WAVE LENGTHS By D. W. Fry and F. K. Coward. Cambridge University Press, 51 Madison Avenue, New York 10, N. Y., and London, England, 1950. 172 pages, diagrams, charts, tables, $8^3/_4$ by $5^1/_2$ inches, cloth, $3.50. Written for both the engineer and physicist, this book gives an account of the theory and application of aerials for use on wave lengths of ten centimeters and less. The theory is presented in physical terms, and elaborate mathematics is excluded. The principles of design, but not the constructional details, are treated, and the advantages of different types of aerials for different purposes are explained.

BASIC ENGINEERING DRAWING. By W. W. Turner, C. P. Buck, and H. P. Ackert. Ronald Press Company, New York, N. Y., 1950. 669 pages, illustrations, diagrams, charts, tables, $9^1/_4$ by 6 inches, cloth, $4.50. Based on results obtained through classroom experience, this book integrates the material from college level courses in engineering drawing, descriptive geometry, and machine drawing. The theory and practice of drawing here presented is in keeping with the latest recommendations of the American Standards Association and with current industrial practice. Numerous problems covering a wide range of subjects and of varying degrees of difficulty are included as well as a glossary of shop terms, equipment, and procedures.

PAMPHLETS

The following recently issued pamphlets may be of interest to readers of "Electrical Engineering." All inquiries should be addressed to the issuers.

Back-Scatter Observations by the Central Radio Propagation Laboratory—August 1947 to March 1948, by W. L. Hartsfield, S. M. Ostrow, and R. Silberstein. A high-power pulsing transmitter and westwardly beamed antenna system were constructed and emissions made from Sterling, Va., on 13,660 kc. 16 pages. Copies available from the Superintendent of Documents, Government Printing Office, Washington 25, D. C., at ten cents each.

Organizing Your Plant for Fire Safety. A manual emphasizing suggested procedures for the guidance of management in regard to fire safety in the plant. Reflects the methods now in use in many of the leading industries and gives a comprehensive discussion of fire causes and their correction based on more than 20,000 industrial fires. 91 pages. Illustrated. Copies are available from the Factory Mutual Engineering Division, 184 High Street, Boston 10, Mass., at $2 each.

Audio Anthology. This 124-page volume is a compilation of 38 articles on the following subjects: amplifiers, phonograph equipment, speakers, tone and loudness controls, noise suppressors, and dividing networks. Available in a paper-bound edition at $2 or hard-cover edition at $3 from Radio Magazines, Inc., 342 Madison Avenue, New York 17, N. Y.

Recommended Practice of Daylighting. Discusses in detail prescribed means for the utilization of daylighting in building design. Pages are illustrated with photographs and charts. 36 pages. Single copies are available at 50 cents each with quantity prices upon application from the Publications Office, Illuminating Engineering Society, 51 Madison Avenue, New York 10, N. Y.

Recommended Good Practice for Selecting and Installing Electrical Equipment in Textile Mills. A guide to the proper use of electric equipment so as to effect a reduction in the electrical fire hazard. 56 pages. Illustrated. Available without charge from Factory Insurance Association, 555 Asylum Street, Hartford, Conn.

International Radio Tube Encyclopedia. Describes more than 14,500 tubes and is the result of years of intensive work under the direction of Bernard B. Babani. Includes a complete description of tube types used by the armed services of the United States, Europe, and Great Britain. Tubes in production but not yet on the market are also described. Copies are available from British Industries Corporation, 164 Duane Street, New York, N. Y., at $6.50 each.

Radiological Laboratory. A 4-page folder describing problems of using radioactive isotopes. Illustrated. Copies may be obtained for ten cents from V. W. Palen, Bureau of Public Information, New York University, New York 53, N. Y.